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Editorial Notes

The Printing Dispute

In common with most other United Kingdom periodicals, "The Dock & Harbour Authority" has been affected by the dispute in the printing industry. In these circumstances it has not been possible to produce the usual number of pages for our July issue. We apologise for the delay in publication and also for the reduction in size, and hope that conditions will have returned to normal by the time our August issue is due for press. We are grateful to our printers for their co-operation in producing the present number despite many difficulties.

Port of Hull Improvement Works

New port facilities at Hull, comprising a wholly reconstructed Riverside Quay and major developments along the south side of the adjacent Albert Dock, were formally opened last May by H.R.H. Princess Royal. Apart from the new Riverside Quay, the works include the quay facing Albert Dock, seven transit sheds, a passenger building, and a system of roads, railways and other facilities including 18 wharf cranes.

These improvements, described in detail on a following page, mark a further stage in the modernisation of the Port of Hull and will do much to strengthen Hull's position as the third port of the United Kingdom. They will enhance its attraction as a port for the Continent, being especially designed to deal with urgent traffic and handle perishables in conjunction with the new fleet of fast Continental cargo vessels. Formerly this trade was conducted under great difficulties and in buildings quite unsuited to modern requirements. Now with increased craneage and the ability to deal with ships at all states of the tide, a faster turnround will be ensured.

Oil Pollution of the Sea

A two-day International Conference on Oil Pollution of the Sea was held in Copenhagen early in July. During the meetings it was announced that two American Committees had recommended that the United States government should ratify the 1954 Convention, and American ratification is expected in the near future. It was thought that some other nations might be induced to follow the lead of the United States, especially the "flag of convenience" coutries such as Panama and Liberia. A message from the Polish Government was also received at the Conference, signifying their willingness to ratify, provided the other countries bordering the Baltic did the same. Denmark, Sweden, Finland and West Germany already support the Convention, but Poland, the Soviet Union and East Germany at present do not.

The Chairman of the Conference drew attention to the fact that the Inter-Governmental Maritime Consultative Organisation had been set up this year with headquarters in London and that it regarded the prevention of oil pollution of the seas as one of its major tasks. Although I.M.C.O. will draw up its own programme of action, the Conference felt it would be helpful to put forward certain suggestions from its experience.

First, it would be of great help to all those countries concerned with this problem if I.M.C.O. would collect information on an international basis about: (a) the adequacy of reception facilities for oily waste at ports; (b) the extent to which the Convention has so far been enforced in courts of law throughout the world; (c) the extent to which codes of conduct have been prepared for ships' officers and have been distributed to them by governments; (d) the extent to which the staff of port authorities in Convention countries are inspecting ships to ensure their compliance with the Convention.

Second, I.M.C.O. should collect reliable information about the value of chemicals for the purpose of separating oil and water and preventing emulsification, and the result of such research should be collated and published. Third, I.M.C.O. should investigate the report on the adequacy of facilities for disposing of oily waste from tankers, who clean their tanks on their way to the ports of loading in the Middle East and elsewhere, and who wish to discharge the accumulated waste upon arrival.

Fourth, I.M.C.O. should urge the ratification of the Convention by those countries which have not yet done so, especially the United States, The U.S.S.R., Poland and Italy. It should be emphasised that the only sure remedy to oil pollution is total prohibition. Fifth, I.M.C.O. should make preparations for a new International Conference with the object of obtaining agreement among all nations that, from a given date, they will prohibit their ships from discharging oil into the sea anywhere at any time.

The Conference also passed a resolution calling for an extension of the prohibited zones laid down in the 1954 Convention.

Traffic on the St. Lawrence Seaway

According to a preliminary statement of toll traffic issued by the Canadian and United States Seaway authorities, 2,243,450 tons of cargo were carried through the St. Lawrence River canals during May, the first complete month of operation since the opening of the Seaway. The cargo was carried by 980 vessels, the aggregate gross tonnage of which was 2,898,800. Compared with May 1958, when the 14-ft. canals were in operation, the increase in cargo was 741,360 tons, or 49%. Cargo tonnage for the Welland Canal for May 1959 was 3,096,650, exceeding that of the corresponding month last year by 355,685 tons, or 13%. The number of vessels entering the canal was 1,022 with a gross tonnage of 4,102,000.

Density Currents and Siltation in Docks and Tidal Basins

by F. H. ALLEN, M.A., M.A.I., M.I.C.E. and W. A. PRICE, B.Sc.(Eng.)

Introduction

The object of this paper is to describe briefly the main features of two investigations into siltation problems in docks and tidal basins in which a major factor was found to be the density currents arising from differences in salinity (or density) between two interconnected or periodically separated bodies of water. The paper claims to be no more than introductory; the **ad hoc** investigation of dock siltation is still in progress and will be succeeded by background research. Only when the latter has been completed will it be possible to draw up quantitative generalizations. However, sufficient has been done to justify a report on the underlying mechanism, to indicate the order of magnitude of the effects and to compare field measurements with existing theory.

Siltation in Queen Elizabeth II Dock, Mersey Estuary, Cheshire

The new Queen Elizabeth II Dock for ocean-going oil-tankers is situated on the south side of the Mersey estuary, with which it is connected by a lock designed to accommodate vessels 650 feet in length. The lock is equipped with sliding caisson gates which prevent run-in at spring tides. The layout is illustrated in Fig. 1, from which it can be seen that the lock and dock are alongside the Manchester Ship Canal with its separate entrance locks at Eastham (which have mitre gates).

The spring tidal range in the estuary at Eastham is about 30 ft, and a typical salinity at H.W. springs is 26 parts per thousand by weight (p.p.th.). Water levels in the Queen Elizabeth II Dock and in the Canal are maintained at a level slightly higher than H.W. of average spring tides. The canal is supplied largely by fresh-water tributaries and also to some extent by run-in through the Eastham locks at high spring tides; its water is therefore less saline than that of the estuary. The level in the dock is maintained by the frequent use of balancing culverts which supply water **from the canal.** The dock water too is therefore less saline than that in the estuary. A typical salinity in the dock is 21 p.p.th., about 5 p.p.th. less than that in the estuary near H.W.; but differences of up to 9 p.p.th. have been observed.

The rate of siltation in the dock varies between 3000 and 8000 cu. yds. per week, and the problem is aggravated by the difficulties involved in using dredgers in an oil dock. The dredged material is almost wholly in the silt range. The problem was submitted to the Hydraulics Research Station, Wallingford, which has carried out a field study and is now engaged on a 1/60-scale model investigation.

Silt can enter the dock in two ways: from the canal through the balancing culverts, or through the navigation lock. Analysis of samples taken from the culvert showed that a negligible quantity of silt entered from the canal, the average concentration of suspended solids being about 20 parts per million by weight (p.p.m.), and values of 100 p.p.m. being exceeded very rarely. It was therefore clear that by far the greater part of the silt must enter through the lock.

Conditions in the estuary immediately outside the lock are favourable to the almost continuous settlement of silt from suspension. A clearly defined layer of unconsolidated silt or mud, with very high concentrations of solids, has frequently been observed outside the entrance. This layer is quite mobile; and as bed levels in the area are slightly higher than those in the lock, the mud layer could gravitate—as a turbidity current—into the lock when the outer gate is opened. Of somewhat greater interest, however, is the effect of the salinity or density difference between the estuary and dock during a normal locking operation. Such operations take place at or near the time of H.W. when the difference in salinity is a maximum. The salinity of the water in the lock is greater than that of the dock but less than that of the estuary. The following description is based on measurements in the prototype, subsequently corroborated and extended by observations in the model.

As the outer lock gate is opened an inflow of the more saline and denser estuary water takes place near the bed, carrying a large quantity of mud (in high concentration) into the lock; and there is a corresponding surface outflow of less saline and relatively clear water from lock to estuary. One result of this process is a significant increase in the mean salinity of the water in the lock. After closing the outer gate, the lock water level is raised by the normal transfer of water from dock to lock through the sluices. The sluice outlets are situated near the bottom of the lock and the high velocity jets produce extensive mixing in the lock. At this stage the salinity of the lock water has been reduced slightly but is still appreciably in excess of that in the dock. When the inner (lock/dock) gate is opened the first stage is repeated, the silt being carried into the dock by the strongly inflowing density current near the bed.

The passage of ships, laden or light, in either direction, complicates the simple process just described and is in fact one of the main objects for study in the model. The effect of shipping, however, is not to alter fundamentally but merely to modify the influence of the density currents. For example, the model has demonstrated that the inflowing density current near the bed is not reversed or annulled by the passage of a lightly laden ship from the lock into the dock.

Before passing to an examination of actual field measurements of the density currents, it seems appropriate to consider the possible solutions to a problem of this kind. One solution might be to impound the dock with relatively clear water of salinity equal to or slightly higher than that or the estuary water outside the lock at H.W. of spring tides; but this would at least entail the very expensive installation of large pumps and a long pipeline. The

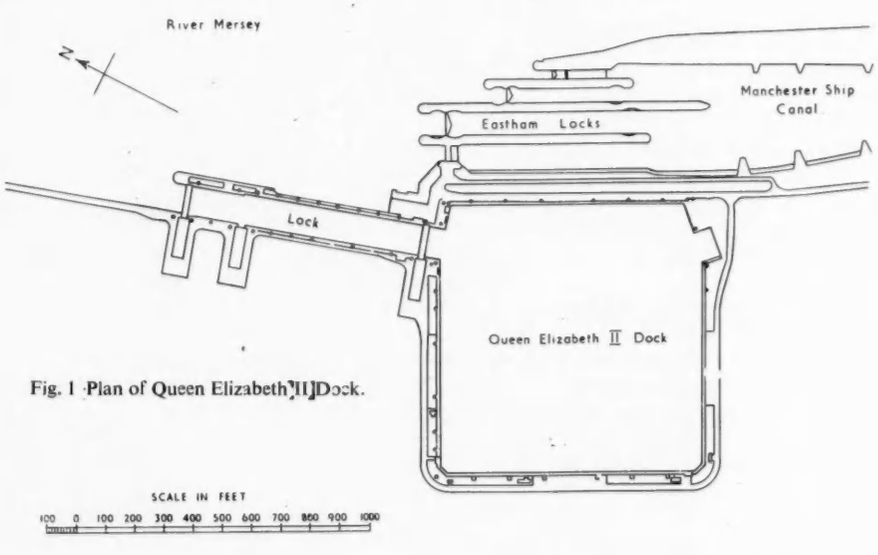


Fig. 1 Plan of Queen Elizabeth II Dock.

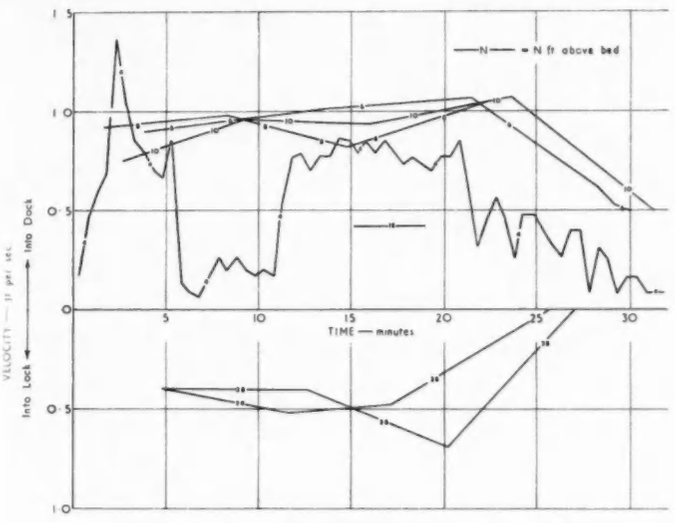


FIG. 2. Velocity of interchange of water between the lock and the dock — Queen Elizabeth II Dock.

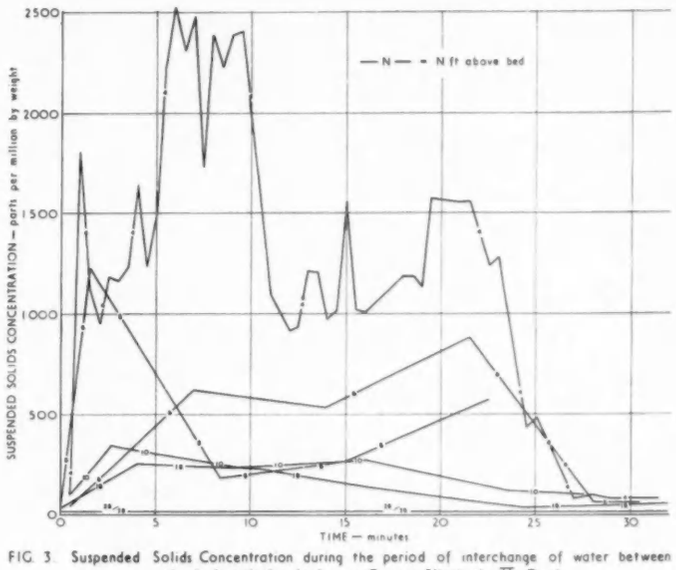


FIG. 3. Suspended Solids Concentration during the period of interchange of water between the lock and the dock — Queen Elizabeth II Dock.

use of any type of submerged sill, to act as a barrier to the inflowing density current, seems to be out of the question in any existing lock designed specifically for a particular size of heavy-draught tanker. The most promising partial solution appears to lie in the use, immediately outside the outer gate, of vertical jets or of turbulent uprising currents. These would be brought into action some time before the gates were opened, so that an appreciable proportion of the mud lying in high concentrations near the bed would be carried in suspension in the upper layers and would therefore, when the gates were opened, be transported away from the lock by the outward-flowing surface current.

Field measurements in lock entrance to Queen Elizabeth II Dock, and comparison with theory.

Observations of current velocities, salinities and concentrations of suspended solids were made at seven depths in the lock while an experimental locking operation was carried out without the added complication of traffic passing through in either direction. Apart from the absence of ships, the operation was a normal one.

The results are shown in Figs. 2, 3 and 4. It would be unwise to base very firm conclusions on only one series of observations, but an examination of these results in the light of existing theory is of some interest.

From theoretical considerations, the velocity of the wave front of a fluid intruding into a fluid of lower density is given by

$$V = 0.707 \sqrt{\left(\frac{\rho_1 - \rho_2}{\rho_1 + \rho_2}\right) gd} \quad \text{(i)}$$

where V = velocity of wave front,

ρ_1 = specific gravity of the denser fluid,

ρ_2 = specific gravity of the less dense fluid,

d = depth of water.

This does not take into consideration any boundary layer effect due to the bed, or any energy loss due to shear at the interface.

An experimental relationship,

$$V = 0.67 \sqrt{\left(\frac{\rho_1 - \rho_2}{\rho_1 + \rho_2}\right) gd} \quad \text{(ii)}$$

was obtained by Yih[1] from experiments carried out in a flume.

To apply these relationships to the lock observations, it has to be assumed that the distribution of suspended solids and salinity was uniform with depth prior to the experiment. Values of salinity are therefore assumed to have been 24.5 p.p.th. and 21.0 p.p.th. for the lock and dock respectively; and the concentrations of suspended solids to have been 500 p.p.m. in the lock and 10 p.p.m. in the dock. Computing the specific gravities from these values, and substituting in the formulae, the following results are obtained.

From equation (i),

$V = 0.955$ ft/sec;

and from equation (ii),

$V = 0.908$ ft/sec.

V has been said to be the velocity of the wave front. It would be more correct to define it as the velocity of the toe of the wave front.

Fig. 5 indicates that the velocity gradient over the highest and lowest quarters of the depth is small, while the greatest rate of change of velocity with depth is in the two centre quarters. In this particular experiment, the depth of water was 40 ft. Thus one would expect the velocities within 10 ft. of the bed to be very approximately of constant magnitude. Reference to Fig. 2 shows this to be the case, with the sole exception of the velocities recorded 4 ft. above the bed (which will be discussed later). With this exception, the velocities can be seen to be about 0.95 ft/sec. The fact that this agrees more closely with the theoretical value obtained from (i) than with that obtained from the experimental equation (ii) is not worthy of further discussion in the light of the assumptions made. The absence of any definite velocity gradient with depth may also be attributed to non-uniform distribution of the salinity and the concentration of suspended solids.

The velocities recorded 4 ft. above the bed do not conform to the accepted pattern of flow set up by density currents. This may be explained by the formation of a boundary layer on the bed, with a consequent deformation of the wave front as shown in Fig. 6. Referring again to the velocities 4 ft. above the bed as shown on Fig. 2, the initial peak velocity is thought to have been due to the disturbance created by the initial opening of the gate. If this peak velocity is therefore ignored, it can be seen that the maximum velocity of flow is about 0.75 ft/sec, compared with 0.95 ft/sec. in the layers above.

The existence of a boundary layer does not however explain the variation of velocity with time. If the curve of velocities is compared with the curve of suspended solids concentrations at the same depth, it appears that the velocity shows a sudden decrease for a corresponding increase in

[1] Yih, Chia-Shun, "A study of the characteristics of gravity waves at a liquid interface". M.S. Thesis, State University of Iowa, Feb., 1947.

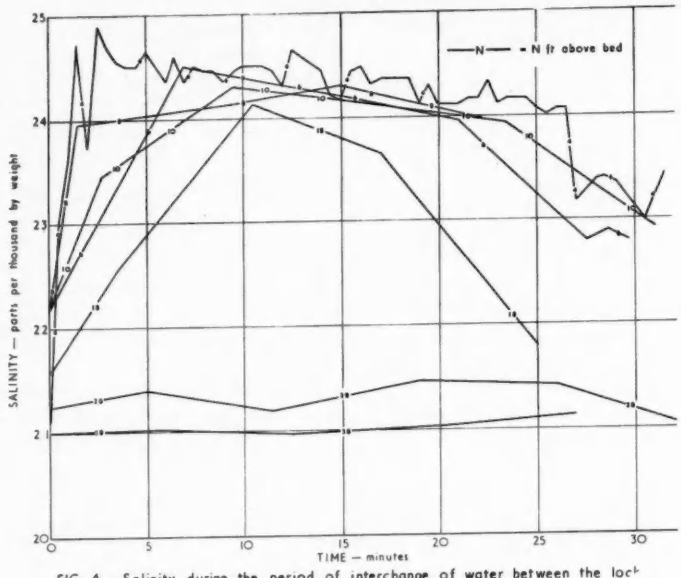


FIG. 4. Salinity during the period of interchange of water between the lock and the dock — Queen Elizabeth II Dock

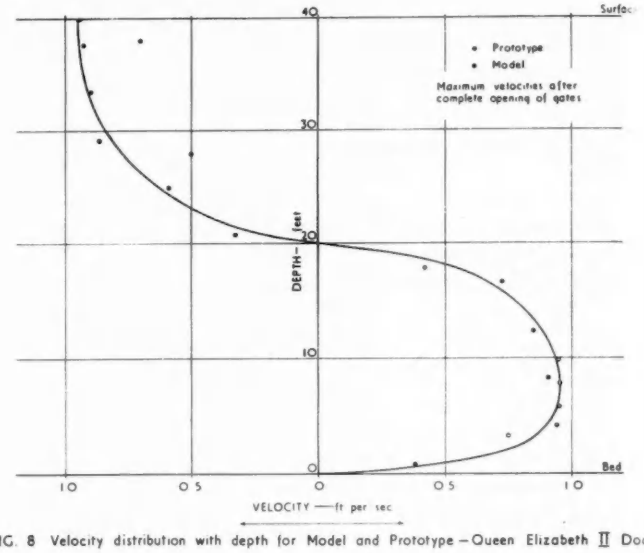


FIG. 8 Velocity distribution with depth for Model and Prototype — Queen Elizabeth II Dock.

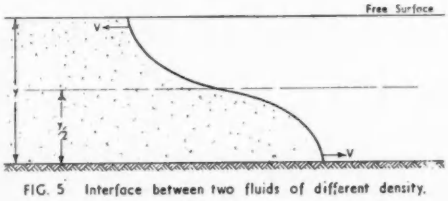


FIG. 5 Interface between two fluids of different density.

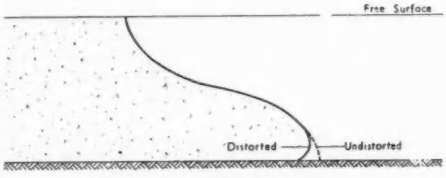


FIG. 6 Interface distorted by boundary layer.

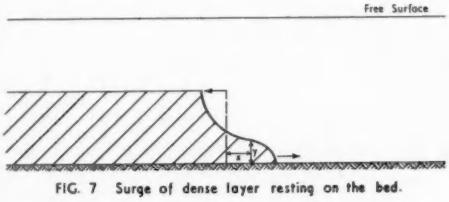


FIG. 7 Surge of dense layer resting on the bed.

the concentration of solids. The explanation of this phenomenon may be that, superimposed on the normal flow pattern, there is a secondary flow generated by a surge taking place in a layer of fluid mud resting on the bed. A study of Fig. 3 certainly suggests the presence of a bed layer, some 4 ft. in depth, containing a substantially higher concentration of suspended solids than the layers above. If the general analysis of surges by Saint-Venant be applied to the case of a submerged layer (see Fig. 7), the following equation is obtained:

$$V = \left(2-3\sqrt{\frac{y}{h}}\right)\sqrt{g^1 h}$$

where h = depth of fluid
y = height above the bed
V = velocity of the interface

$$g^1 = \frac{\Delta\rho}{\rho} g, \left(\rho \text{ being the density}\right)$$

Applying this equation, taking the concentration of solids as 2300 p.p.m., and $h=y=4$ ft, the resulting velocity $V = -0.42$ ft/sec, 4 ft. above the bed.

In the lock, the velocity 4 ft. above the bed, prior to the intrusion of the fluid mud layer, was 0.75 ft/sec. Thus the net velocity during the passage of fluid mud should be

$$V = 0.75-0.42=0.33 \text{ ft/sec.}$$

In the experiment a velocity of 0.2 ft/sec. was actually observed during this period.

It must be pointed out that in computing the opposing velocity, only the concentration of solids near the upper boundary of the fluid mud layer was used. It is probable that the mean concentration of solids in the layer would be considerably higher, resulting in a smaller net velocity and better agreement with the observations.

The 1/60-scale model will provide the means to study the two types of density current flow independently. Up to the present the experiments have centred on the salinity-density effect, and the boundary-layer deformation has been confirmed. (See Fig. 8).

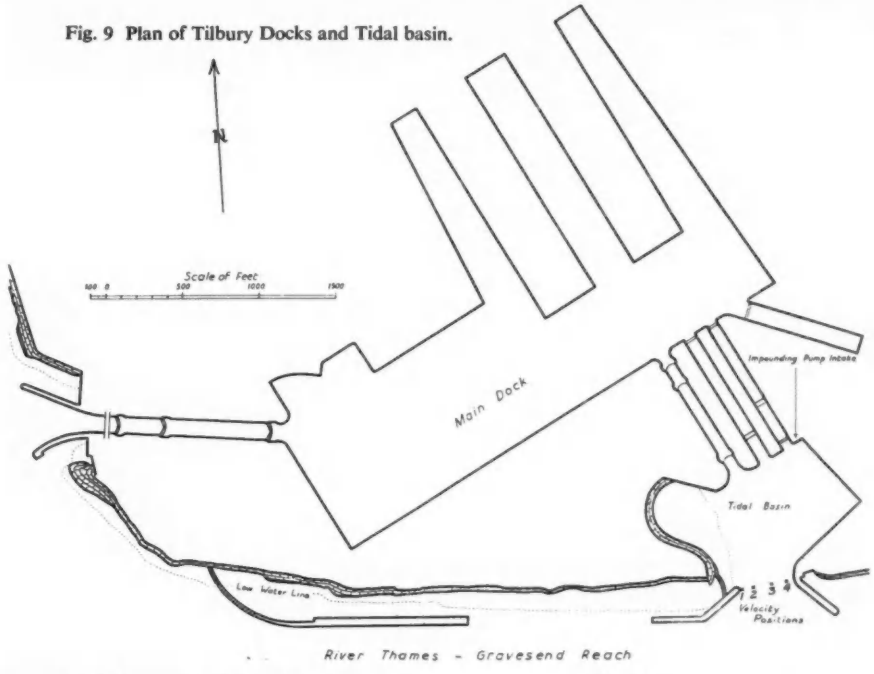
Siltation in Tilbury Tidal Basin, Thames Estuary, Essex

In the case of a tidal basin, adjoining and permanently open to an estuary, the fluctuating difference in density between the basin and the estuary is an important factor in the almost inevitable siltation problem, although the actual density currents may often—when the estuary is well-mixed—be less clearly defined than they are in navigation locks. This is well illustrated by conditions in Tilbury Tidal Basin on the Thames estuary, some 26 miles below central London, where the spring tidal range is about 20 ft. A plan of the basin and its environs is shown on Fig. 9. In an effort to maintain a depth of 24 ft. below L.W. spring tides, about 400,000 cu. yds. of silt are dredged from the basin each year. This problem was investigated jointly by the Port of London Authority and the Hydraulics Research Station, Wallingford, by measurements in the prototype and by experiments in a 1/600-scale model of the tidal Thames.

For some miles upstream and downstream of Tilbury the estuary water carries a heavy load of silt in suspension, the concentrations being particularly high in the lower layers during the early stages of the flood tide[2]. The silt charge is especially high near the entrance to the basin, where silt or mud concentrations of about 50,000 p.p.m. were frequently observed near the bed. Apart from these layers of "fluid mud", it was found that the suspended load near the bed was four or five times that at the surface during the early stages of the flood.

Early in the investigation it was established by field observations that the main inflow to the basin during the flood tide took place at the bed—heavily silt-charged water being carried into the relatively tranquil basin where deposition naturally ensued. The results of prototype velocity and direction observations across the entrance to the basin for a complete tidal cycle are shown in Fig. 10. The bed flow

Fig. 9 Plan of Tilbury Docks and Tidal basin.



was particularly marked during the latter half of the flood. During the ebb, water flowed slowly out of the basin at all depths, the outflow near the bed being dominant in the latter stages. Another feature of conditions during the flood was the formation of a slow eddy in the basin and the co-existence of an outward flow from the basin in the surface layers with an inflow at the bed. This circulation implied that a greater quantity of silt-laden bed-water was entering the basin than was required for filling the tidal prism. It followed that siltation took place in the basin as a result of the bed inflow during the flood tide, and that any solution must be aimed at improving the entry conditions.

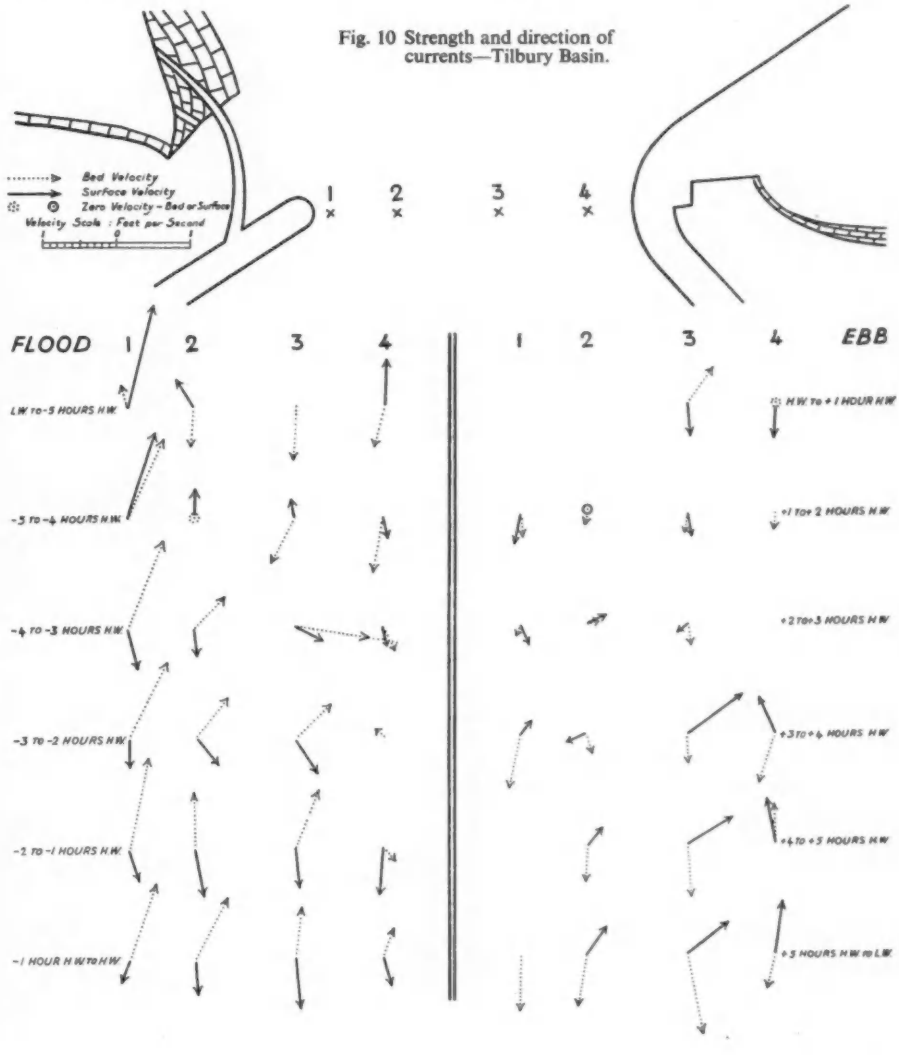
The first model experiments were conducted without attempting to reproduce the variation in density of the estuary water during the tidal cycle. It was found possible to simulate the prototype flow patterns approximately but conditions were somewhat unstable, being sensitive to minor changes in bed level at the entrance and in the structure of the adjoining jetties. Furthermore the influx of bed water during the latter stages of the flood was much less positive than the corresponding flow in the prototype.

The model was then adapted for the reproduction of salinities, with a density scale of unity, by the injection of sodium chloride solution. The linear scales of the model were 1/600 horizontally and 1/120 vertically. The longitudinal and vertical distributions of salinity throughout the model estuary were in excellent agreement with prototype data[2], indicating that turbulent mixing was of the right order. Under these model conditions it was found that the flow patterns at the entrance to Tilbury Basin, and within the basin, were an accurate reproduction of prototype behaviour. In particular the effect of the tidal variation in density was to increase and sustain the inflow of bed water in the latter stages of the flood tide.

The relative variations in the salinity of the water in the basin and just outside the entrance during a typical tide are shown in Fig. 11. It can be seen that the salinity range in the basin is considerably less than that of the estuary. At about half flood the salinity in the estuary exceeds that in the basin, and the difference increases until H.W. This difference produces a marked inflowing density current which reinforces the usual inertia forces and strengthens the silt-bearing flow into the basin. In the latter half of the ebb the

[2] Inglis, C.C. & Allen, F.H., "The regimen of the Thames Estuary as affected by currents, salinities and river flow", Proceedings of the Institution of Civil Engineers, Vol. 7, August, 1957.

Fig. 10 Strength and direction of currents—Tilbury Basin.


Bed Velocity
Surface Velocity
Zero Velocity - Bed or Surface
Velocity Scale : Feet per Second
1 2 3 4
FLOOD
EBB
LW to -5 HOURS H.W.
-5 to -4 HOURS H.W.
-4 to -3 HOURS H.W.
-3 to -2 HOURS H.W.
-2 to -1 HOURS H.W.
-1 HOUR H.W. to H.W.
H.W. to +1 HOUR H.W.
+1 to +2 HOURS H.W.
+2 to +3 HOURS H.W.
+3 to +4 HOURS H.W.
+4 to +5 HOURS H.W.
+5 HOURS H.W. to L.W.

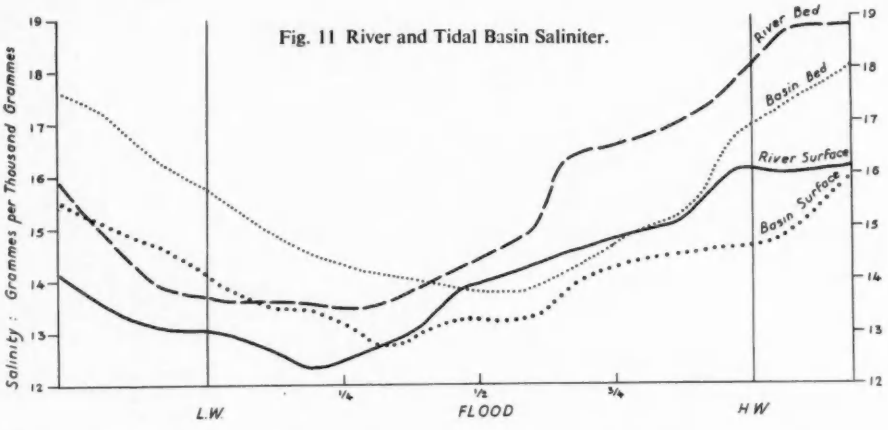


Fig. 11 River and Tidal Basin Saliniter.

situation is reversed, the salinity of the basin exceeds that of the estuary, and an outflowing density current reinforces the normal ebb from the basin. However, these ebb currents are not sufficiently strong to scour and evacuate the silt which has entered and deposited in the basin during the flood and at H.W.

It is not proposed to discuss the many schemes that were tested in an attempt to reduce the inflowing bed current of silt-laden water or to delay its onset. Were it not for the density currents the practical problem would be relatively easy to solve; it was found that both the circulation within the basin and the tendency for bed inflow of water of uniform density could be prevented by a guide wall and by narrowing and re-aligning the entrance. Such works would be worthwhile as they would undoubtedly reduce the rate of accretion in the basin. Nevertheless it would seem that a complete solution to the problem cannot be found if the basin is to remain tidal, for the effect of the tidal variation in density is fundamental and inescapable. It might be argued that the density currents could be counter-acted if large quantities of denser (and silt-free) water were pumped into the basin from a lower reach of the estuary, but such a solution, at least in the case of Tilbury, could not be justified economically.

Acknowledgements

The authors would like to acknowledge the assistance of the Port of London Authority in the investigation of Tilbury Tidal Basin, and the experimental work carried out by Mr. C. F. Porter at Tilbury and on the Thames model. They also wish to acknowledge the co-operation of the Manchester Ship Canal Company, the field work by Mr. J. D. G. Smart on the Mersey estuary and the Q. E. II Dock; and the experimental and theoretical studies by Mr. P. Rance at the Hydraulics Research Station.

Launch of Caisson for Hinkley Point Atomic Power Station

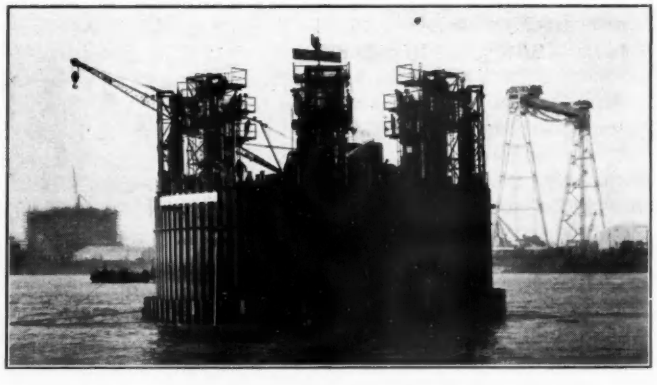
A concrete Caisson, weighing 3,900 tons, was recently towed 2,000 feet into the Bristol Channel to act as the cooling water intake caisson for the Hinkley Point atomic power station, Somerset. The caisson, a cylinder 60 ft. high and 90 ft. diameter is an intricate structure of reinforced concrete columns and ribs; it is supported on the sea bed on eight adjustable steel spud legs 68 ft. long and 4 ft. diameter. For the floating operation, it was fitted with a built-in false bottom of timber, supported by structural steelwork.

The operation was carried out by the combined crews of Taylor Woodrow Construction Ltd., of London, civil engineering contractors for Hinkley Point, and their towing contractors, Metal Industries (Salvage) Ltd., of Helensburgh. Its success depended on very accurate timing. The tides only allowed four hours of sufficient depth of water to launch the caisson, tow it to position and ground it. Such a tight schedule had many hazards, unpredictable weather being the foremost.

After consideration of an elaborate system of forecasts and site recording instruments, the decision to leave the dock was made at the latest possible time. The caisson was winched northwards by the boom defence vessel 'Plantaganet' through a carefully prepared dredged channel of limited depth and width in the rocky foreshore. Once outside the dredged channel, the tow was taken up by the ocean going tug 'Metinda', through the surveyed and buoyed channel into deper water, before reaching the sinking zone.

With all craft and the caisson in radio communication, the tow proceeded into the dropping area, whereby a system of visual markers, and the use of anchors laid previously, the caisson was moored approximately in position after a tow of about two-thirds of a mile.

Final positioning was by winching on the caisson's own winches to more precise directions given by radio from shore-based instruments, and was carried out to the precise requirements dictated by the line and position of the tunnels already driven to a point in close proximity to the caisson.



The caisson under tow, with the power station reactor buildings, left background and the Goliath crane on right.

Having achieved a satisfactory location in conditions of strong and variable currents and rapidly falling tide of 35 feet range, the caisson was grounded on its eight spud legs extended to pre-determined lengths based on accurate sea bed surveys.

From this stage forward all afforts were concentrated to take up evenly on all spud legs the increasing load as the caisson lost its buoyancy on the falling tide. The 500 ton hydraulic jacking system operating the legs was also utilised to maintain the caisson level in itself and relative to Ordnance Datum counteracting the ground penetration resulting from the increased spud loadings.

On achieving maximum loading and level conditions, the main flooding valves were opened to render the caisson tidal and the

Hinkley Point Caisson—continued

operation was completed some eight hours after leaving the construction dock.

The final work was to construct an aerial ropeway which will carry materials and personnel 2,000 feet over the Channel to the caisson. Work began on this as soon as the caisson was grounded.

Cofferdam for Off-shore Tunnelling

Around the caisson as it was towed was a sheet pile structure which, when driven into the sea bed, will form the cofferdam within which connections to the cooling water tunnels will be constructed.

Two cranes taken out as part of the caisson's cargo are now at work in preparing to form the cofferdam, which will allow a shaft to be sunk 40 feet into the sea bed to connect with the water tunnels. These 12 feet diameter tunnels are already nearing completion, and driving is rapidly reducing the distance left at the rate of 100 feet per week.

The seven-feet diameter access tunnel is already within a short distance of the caisson, and will be linked with the shaft as soon as this is proof against the sea.

The contractors were faced with a tight time schedule for the whole operation. Final survey and design requirements enabled design of the caisson to be started in March, 1958. The construction of the dry dock in which to build the caisson started in May, and the construction of the caisson itself in October, 1958.

National Dock Labour Board

Abstracts from Annual Report for 1958

The 12th annual report and accounts of the National Dock Labour Board for 1958, which was published recently, mentions that the Board, in common with other similar bodies, has encountered occasional criticism in the press and on radio and television programmes. Although some of this criticism has been inaccurate and ill-informed, the view is still held that in the interests of the industry as a whole the Board should concentrate on its efforts to provide an efficient service. Therefore, beyond publishing factual information, as for example, that given weekly in respect of the disposition of the labour force, the Board has resisted the temptation to enter the arena of popular controversy.

As regards the labour position, the underlying trend for the greater part of the year was one of declining labour requirements. The closing weeks of the year, however, showed signs of recovery, and whilst the inclusion of both Christmas and New Year holidays within the period tended to suggest that the improvement was only of a temporary nature, it is nonetheless encouraging that a higher level of employment has continued into the opening weeks of 1959. Taking 1958 as a whole, although for statistical purposes this included 53 working weeks as compared with 52 in 1957, the aggregate normal turns worked by registered men showed a reduction of 5% on the previous year.

The causes of this trend were somewhat complex and throughout the year it provedunusually difficult to foresee developments in the immediate future. Taking the number of normal turns worked week by week as a rough and ready barometer, the fall in the early months of the year was undoubtedly due in large part to the intensity with which credit restrictions were still being enforced, coupled with a reduction of import quotas by a number of other coutries on whom our export trade depends. By the summer, world trade was feeling the effect of the recession in the United States, while the improvement by the end of the year suggested that at least a modest expansion might be expected in 1959.

The Board made substantial reductions in sanctioned labour strength during the year and standstill orders were made in a number of areas. The conditions in which the Board undertook its first half-yearly review of sanctioned strength prompted reconsideration of a general temporary release scheme similar to that introduced in 1952. The circumstances, however, were not entirely similar for, although the levels or employment were comparable, the registers were substantially lower during 1958. Generally speaking, it had also to be accepted that the prospects of readily securing alternative employment for a temporary period were not so good as previously. However, after consideration of local circumstances 17 Local Boards adopted modified arrangements, and at the end of the year 210 men were on release—a modest number which nevertheless has contributed in small measure to reducing the Board's liability.

The average numbers of men employed on probationary, temporary and seasonal registers during 1958 amounted to 806, whereas the corresponding figure for 1957 was 1,619. The maximum numbers of such men also fell from 2,399 in 1957 to 1,029 in 1958. Most of the reduction was attributable to the probationary registers, from which 742 men were transferred to main registers, while a further 303 left the industry. At the same time, opportunities for new recruitment were particularly restricted in those areas where Local Boards have adopted the principle of probationary service. Direct intake was reduced from 4,048 in 1957 to 1,803 in 1958, while direct outflow from the industry was only slightly less than in 1957, there being the following net changes on the registers: main registers down by 2,336, probationary register by 803, temporary register by 36 and seasonal register reduced by 31, a total decline of 3,246.

The report remarks that the year was unfortunately marred by a serious dispute in the Port of London, in the course of which 333,722 man/days were lost. Other disputes involving a loss of 25,063 man/days were overshadowed by this event, which commenced on 13th May with 400 men in the Upper Pool sector of the port supporting strike action by market workers at Smithfield, though the cause of the market dispute was quite unrelated to the conditions of dockworkers. The subsequent spread of the stoppage involved nearly 20,000 men and affected all sectors of the port before work was resumed, the vast majority of the men reporting for duty on 23rd June.

The relatively small number of new recruits to the registers in 1958 substantially reduced the need for training additional specialists, and the numbers trained under schemes financially supported by the Board fell to 107 from 297 in the previous year. The numbers trained included checkers, crane drivers, deal yard carriers and lighterage apprentices, the total cost to the Board being £2,014.

Throughout the year 47 medical centres, staffed by 65 state registered nurses, were in use and gave valuable service by providing immediate skilled attention for the many minor accidents attendant upon dock work, and treatment prescribed by individual medical practitioners which, by obviating attendance at hospital or surgery, saved a substantial amount in time and earnings. Although the reduced level of activity caused some reduction in the use of the centres, nearly 227,000 treatments were given during the year to persons employed on the docks, of whom roughly three-quarters were registered dock workers. As in previous years, the employers of the other men contributed towards the cost of this service.

In 1956 and 1957 the Board met, from reserves set up in Levy Stabilisation Fund for this purpose, the sum of £660,000 by which its income fell short of its ordinary expenditure. By the beginning of 1958 it was fairly clear that the declining volume of dock work, combined with increased charges beyond the Board's

National Dock Labour Board—continued

control (notably in respect of contributions to National Insurance), would produce a deficit in the ensuing year, which might well exceed £¾ million and, unless this trend could be checked, the remaining reserves would be rapidly reduced to a dangerously low level, if not completely exhausted.

Despite these poor prospects, the Board sought not to add to the industry's difficulties and decided to continue the rates of percentage payments fixed in June, 1956, in the hope that some recovery in trade might help to defer the need for action until higher charges could more easily be borne. However, by mid-September expenditure had already outstripped income by more than £750,000. Although the labour force had been reduced, the deficit for the year then appeared likely to exceed £1 million and the immediate outlook gave little indication that the drain on available resources could be contained within prudent limits. From 1st November the Board was therefore reluctantly compelled to raise its percentage payments on gross wages as follows:—

Daily workers employed on work other than coastal traffic ... ... from 12 to 13½%

Weekly workers employed on coastal or other dock work ... ... from 4 to 4½%

The levy on the wages of daily workers employed on coastal traffic was left unchanged at 8% in recognition of the special problems with which this section of the shipping industry is confronted.

In making these adjustments the Board specifically confined itself to recovering from employers the additional basic charges it had been called upon to meet since the previous rates of levy were fixed, and did not seek reimbursement for the current deficits attributable to the recession in trade.

In the event, the higher rates of levy during the last nine weeks of the year, the wage increase introduced in September and improved employment towards the end of the year combined to produce results which were better than had at one time been feared.

Total operating costs rose by about £440,000 to £5,997,781, but allowing for the variation in the market value of investments, actual expenditure increased by some £533,000 Of this gross increase, higher contributions to National Insurance accounted for £243,000, while payments of attendance money and guarantee make-up absorbed a further £295,000 because of lower average employment.

Expenditure from Capital Reserve Fund on premises and equipment showed a further slight decline at £232,873 as against £245,307 in the previous year. This trend was expected and will continue since most major projects have now been completed. According to the latest estimates, the unexpended portion of this Reserve is sufficient to cover the remainder of the building programme at present authorised or contemplated, and no further appropriation of funds has been necessary in the year under review.

The calls made upon Levy Stabilisation and other Funds were mainly met from investments in Government securities redeemable during the year or early in 1959, and the Board is satisfied that the distribution of its remaining investments is such that it can face with confidence any foreseeable demands upon them. A lower Bank rate and a better market tone brought a substantial improvement in stock values at the date of the Balance Sheet, and this has released £71,425 of the provision for potential loss previously held on this account which is now reduced to £135,884.

Fendering on Jetty at Northfleet

An extension to the existing wharf and a new pulp unloading jetty have recently been completed at Northfleet for the Bowater Thames Paper Corporation Ltd. The jetty runs parallel with the existing wharf, the outer face being used for berthing the larger pulp ships and the inner as a barge berth. The jetty has a heavy reinforced concrete deck slab cast in situ which is carried on vertical and raking concrete filled Rendhex No. 4 piles up to 80 ft. long. The jetty is approximately 600 ft. long and 50 ft. wide, and carries 4 No. 5-ton cranes.

The new jetty, view looking east.

On the berthing face, dredging has provided a water depth of 33.5 ft. at L.W.O.S.T. and the jetty is designed to handle ships of up to 12,000 tons displacement.

The fendering arrangements are somewhat unusual and deserve special mention. Nine groups of three fenders each are provided, spaced at 57 ft. 6 ins. centres along the jetty face. Each fender consists of a double H form reinforced concrete block, suspended by two chains from the jetty slab and carries elm rubbing strips on the river face. One group of three fenders is designed to absorb the energy of a berthing ship. Energy absorption is by 12 No. Goodyear rubber cylinders grouped at two levels, the upper level cylinders bearing against a heavy reinforced concrete waling spanning across 7 of the Rendhex foundation columns. This waling was cast in situ and is backed by precast reinforced concrete raking struts which carry part of the horizontal thrust on the fender units to the deck slab. Fig. 1 gives a cross section through the jetty and Fig. 2 shows the arrangement of the fendering system.

The precast concrete fender units weighed approximately 17 tons each and handling these heavy items into position presented some problems. The units were cast in two rows along the completed deck slab in positions as close to their final locations as was convenient. The Rendhex piles of this jetty had been driven with a Menck M.R. 40 pile frame. This frame with its leaders removed was rigged as a crane and ran on rails on the jetty deck so that it could lift the units from where they were cast into position. This proved a very effective means of handling the units and the work of slinging all 27 into position was completed in five weeks.

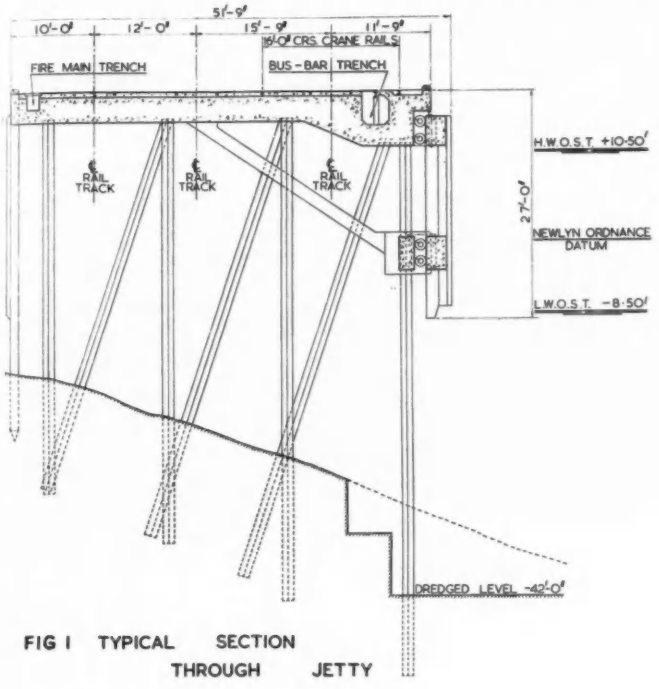
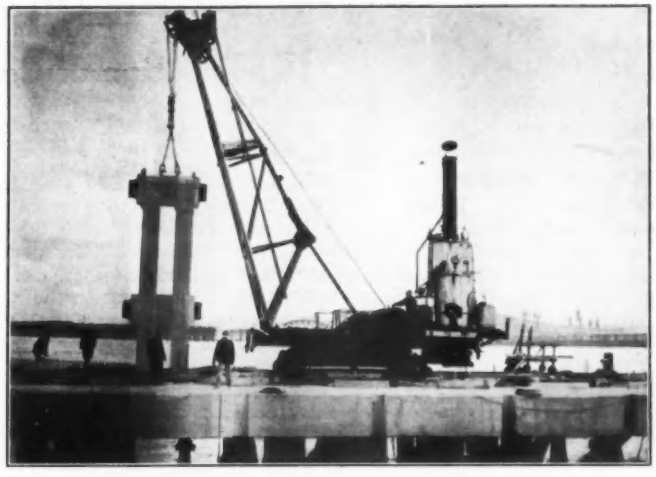


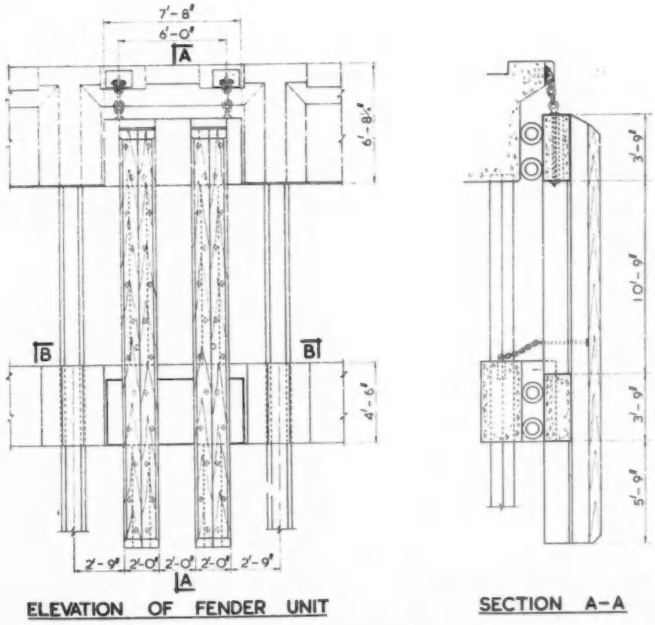
FIG 1 TYPICAL SECTION THROUGH JETTY



Handling precast concrete fender units.

The fendering work, inclusive of the Goodyear rubber units, cost approximately £29,000.

The Consulting Engineers for the Northfleet Jetty were Sir Alexander Gibb & Partners, and the work was carried out by Messrs. J. L. Kier & Co. Ltd.



ELEVATION OF FENDER UNIT

SECTION A-A

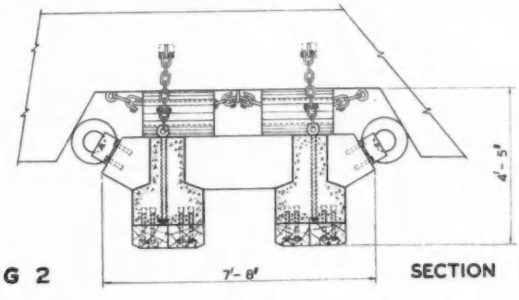


FIG 2

SECTION B-B

Pollution Study of Thames Estuary

For the past 10 years the Water Pollution Research Laboratory, of the Department of Scientific and Industrial Research has been engaged in a study of the Thames Estuary, primarily to provide information on which a Departmental Committee of the Ministry of Housing and Local Government can base recommendations for improving the condition of the estuary.

It was previously known that pollution was due to the production of sulphide when the water became anaerobic owing to organic pollution, and the main task of the Laboratory has been to study the factors which determine the distribution of dissolved oxygen, and also of nitrate which can supply oxygen under certain conditions.

The relations between the distribution of dissolved oxygen and factors such as temperature, and flow of fresh water into the head of the estuary have been examined, using both the results of surveys made by the Laboratory, and records over a long period made available by the London County Council.

The load introduced to the estuary by polluting discharges of all types has been estimated. The largest source of pollution was found to be the effluent discharged from the sewage outfalls of the London County Council; although no recommendations have yet been made by the Departmental Committee large extensions to the sewage works of the L.C.C. are far advanced and are partly in operation. The amount of oxygen available from various sources for oxidizing the polluting load has been calculated. It has been found that the most important source is that absorbed from the atmosphere through the water surface.

A theory of mixing developed at the Laboratory has been used to calculate the distribution of polluting matter introduced at various points. Predictions on the basis of the theory have been confirmed by observations, and calculations of improvements which could be expected if certain changes were to be made in the amount or position of existing polluting discharges are now in progress.

New Refrigerated Warehouse at Amsterdam

Description of Cold Store " Amerika "

BLAAUWHOED N.V. is an enterprise founded in 1616 by one of the groups of merchandise porters who wore blue coloured hats in order to be distinguishable from other groups of the porters' guild. After the extension of its field of operations, the development of activities in other areas, amalgamation with similar enterprises and adaptation to the requirements of the time, this porters' warehousing enterprise has grown to be the largest general warehousing business in the Netherlands.

As the first of its kind in the Netherlands in 1905 this general warehousing company took up the storage of cooled and frozen articles, for which purpose an old general warehouse was provided with insulating and refrigerating equipment. Afterwards, Blaauwhoed N.V. further developed in this line of business; at present the company has five cold stores (Amsterdam and Rotterdam). Two such warehouses converted into cold stores, named " Amerika " and " Australië " and located at Amsterdam, together formed one block of buildings having a common refrigerating system connected to one engine-room in the building " Amerika." After a fire had occurred in 1948, " Australië " could soon be put into service again. " Amerika " was to be rebuilt.

Plans for this rebuilding were prepared but a serious set-back was formed by the circumstance that the old engine-room occupied part of the site on which the building was to be erected and this engine-room had to be kept running so as to refrigerate the cold store " Australië."

This complication necessitated first of all construction in two stages and secondly the placing of the new engine-room on the 5th floor owing to lack of ground-floor space. The eastern (first) stage of construction, with the new engine-room on the fifth floor, was completed in 1955. When new machinery was ready to take over the refrigeration also of the cold store " Australië," the old engine-room was pulled down to make way for the second (western) part of the cold store " Amerika," the construction of which was completed in 1958.

Another complication, in some respects calling for unusual solutions as regards refrigerating technique, was the variability in the nature of the articles received by a general warehouse for storage. For this reason the construction had to be such that each space should be suitable for storage at temperatures of about 0°C (32°F) with forced circulation as well as for storage at low temperatures (down to −30°C or−22°F) with natural circulation. In designing the cold store " Amerika " the aim has been to combine the two storage systems in an equipment suitable for both. This double usage is indeed characteristic of the plant.

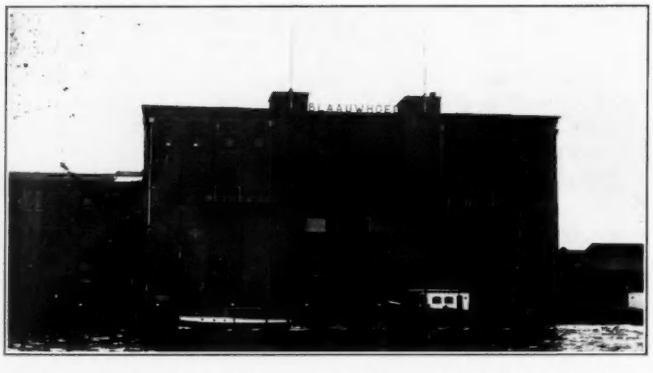


Fig. 1. Front of the building (viewed from North to South). The adjoining water is a harbour of the river " Y," which in ancient times was a tidal stream but is a dock area nowadays with connection to the sea by a canal with locks.

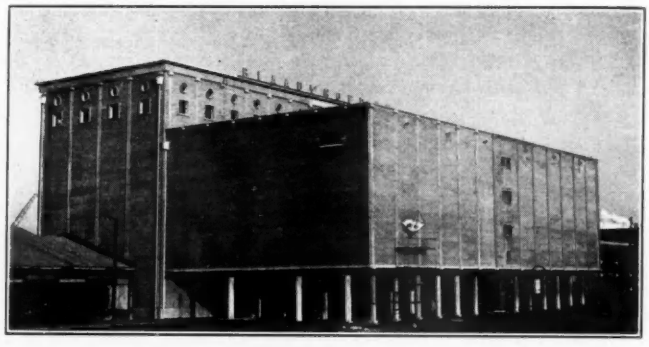


Fig. 2. View from the South. The emblem of the company, a blue hat, can be seen from a distance. The road and the railway-track are roofed over by the 2nd, 3rd and 4th storeys.

After the first pile for the foundation of the new building was driven on July 17, 1952, the construction of the eastern wing and the central section was started on November 3, 1952. The last pile of this first stage (No. 428) was driven on December 5, 1952. This part was completed on August 4, 1955. Refrigerated space could be put into service by the autumn of 1955. On December 19, 1955 the new engine-room started refrigeration. The cold store " Australië ' was then switched over to it and the demolition of the old engine-room was commenced at once.

The first pile for the second stage of construction was driven on October 25, 1956 (the last pile, No. 90, on November 22, 1956). The erection of this western wing started on December 7, 1956, and this wing was completed on December 24, 1957.

In the course of 1958 the remaining cold storage space was put in operation, and after final completion of building and plant the official opening took place on December 1, 1958.

BUILDING

Position and Transport Facilities

The cold store " Amerika " is situated at No. 25, Oostelijke Handelskade, Amsterdam, at the harbour on the river Y (depth 10.30 m), in the centre of the dock area where the terminals of the shipping companies are concentrated. Railway tracks along the store provide easy communications by land; there is convenient communication with Amsterdam and the roads to the hinterland

The utmost care was bestowed on the facilities for internal transport in the building; the use of modern equipment enables rapid receipt and delivery of cooled and frozen goods. On the north side seagoing vessels discharge by means of gantry cranes direct on to balconies completely shaded from the sun. Electric lift trucks and platform-trucks transport the goods immediately after discharge to the cooling and freezing rooms. Cold losses are thus restricted to a minimum. As a result there is no risk of goods being defrosted. On both water and land sides railway vans and trucks can be loaded and unloaded, again without serious consequences for the chilled or frozen goods. The upper storeys on the south side have been built directly over both the road and the railway track, so that refrigerated vans and trucks can be loaded and unloaded without any hindrance from sun or rain. Moreover, trucks can enter the delivery hall of the building. The corridors on the first and second floors are 6 metres wide and permit easy transport to the refrigerated rooms; in addition free

passage of the insulated doors of these rooms has been provided for motorised transport. Self-closing swing-doors limit the loss of cold when the refrigerator doors are opened. For vertical transport in the building three electric goods lifts are available. Each of them has a carrying capacity of 3,500 kg (7,700 lb) and a cage speed of 64 cm per second (126 ft/min). The two lifts placed symmetrically in relation to the central part serve all floors; the third lift connects only the ground floor with the first, second and third floors. A public address system ensures rapid contact with persons throughout the cold store and the adjoining building " Australië."

Dimensions and Lay-out

The cold store the lay-out of which is represented schematically in Fig. 3 has a gross cold storage capacity of 20,202 m³ (714,000 ft³) and a storage capacity of 10,000 m² (353,000 ft²) for general goods.

Lift engine-rooms for 2 lifts	**6th floor**
Canteen Toilets Changing room	**mezzanine**
Central hall Engine-room Various workshops Battery charging room for electric trucks Condensers Chief engineer's office	1,420 m² (15,300 ft²) **5th floor**
Lines room, storage space, butter testing room Ammonia distributing station Boiler-house for central heating Intermediate cooler for lower temperatures Engine-room for 3rd lift	1,420 m² (15,300 ft²) **4th floor**
Loft for storage of uncooled goods 2 loading and unloading platforms	3,320 m² (35,700 ft²) **3rd floor**
7 large and 2 small cold chambers Central transport hall Passages Loading and unloading platform	3,320 m² (35,700 ft²) **2nd floor**
7 large and 2 small cold chambers Central transport hall Passages Loading and unloading platform	3,320 m² (35,700 ft²) **1st floor**
2 cold chambers Central delivery hall Offices and staff rooms Transformer room High and low tension rooms Weigh-bridge	1,420 m² (15,300 ft²) **ground floor**
Cooling water pump room Fire-fighting plant Cycle shed	**cellar**
Bog **Sand** **Soil**	

Fig. 3. Schematic lay-out of the cold store.

In other words: 6,000 tons of frozen goods and 3,000 tons of general goods can be stored. (In addition, the adjoining building " Australië " can store another 3,000 tons of frozen goods.)

The Y-side front has a width of 65.5 metres (215 ft), and the depth of the building on the ground floor is 22.3 metres; the projecting storeys have a depth of nearly 51 metres (167 ft). The greatest height of the building is 32.23 metres (105.9 ft) above street level.

Foundation and Skeleton

As is usual with soft soils the cold store " Amerika " is built on piles. These piles were driven through a thick layer of bog until they came to rest on a layer of sand, located about 14 metres (46 ft) below the surface of the town. The building rests on 518 concrete piles (Franki system) each of which has a permissible load of 80 tons.

The skeleton is of armoured concrete and the floors are constructed as mushroom floors. Above and below the floor of the third storey are cold chambers; the second floor is thus the only floor in the building affected on both sides by the temperatures of the cold chambers. (The cold chambers on the ground floor are separately insulated.) This floor was constructed detached from the surrounding walls, bordering columns having been constructed as double columns, and can therefore shrink under the influence of the low temperatures without harm to the other parts of the building. No secondary stresses are raised. Owing to a joint construction in the floor of the third storey the cork insulation is continuous. The outer walls are constructed as hollow walls and consist of an inner wall of single-brick Poriso and an outer wall of single light yellow hand-formed brick. The main building is covered with pumice-concrete bay plates ; the construction overlapping the wharf has shed-roofing, made of pumice-concrete (so-called " bims " concrete).

Engine-room, Piping, Heating

The engine-room required much space and to keep the ground floor free for other important functions it was planned on the fifth floor. The floor of the engine-room is nearly 23 metres (76 ft) above ground level. The refrigerating lines run from the machines to the cold chambers via the fourth floor, where they enter an insulated space in which the lines branch out and valves for the control of refrigerators have been installed. The valves in this cold space are not insulated and a very light insulation was sufficient for the lines. From this control room the lines pass through four insulated vertical channels to the cold chambers.

The electric cables run through shafts on either side of the lift shafts, where atmospheric temperatures prevail and therefore no condensation can take place. On each floor branches to the cold chambers run via the passages. The cooling water lines also run through separate shafts at the back of each of the two lift

Fig. 4. Electric forklift-truck operating in cold chambers. Note the protection against impacts by means of wooden screens or stakes.

Fig. 5. Engine room. From left to right: desk (distant reading thermometer installation, forced air circulation switches); gauge panel; compressors; condensers.

shafts. All these constructional features make for a convenient arrangement, each kind of line having its own track.

The staff rooms, the engine-room and some other spaces are heated by oil-fired central heating. The boiler for this installation, having a capacity of 300,000 kcal/hr (1,200,000Btu/hr) is placed on the fourth floor; a fuel tank having a capacity of 10,000 litres (2,200 galls) is located below ground level.

REFRIGERATING FACILITIES

General Remarks

Of the 20 cold chambers in the building, the two on the ground floor are chiefly intended for the rapid freezing of fresh products. Two rooms on the first floor also have a higher evaporator capacity for rapid freezing, and another refrigerator for this purpose was constructed on the second floor. The remaining 15 cold rooms are used not for freezing but for storing chilled and frozen goods. A space for butter testing provided with so-called daylight shutters located on the fourth floor may be used for chilled and frozen goods, but this space may also be used for thawing butter and similar articles by passing hot ammonia gas through the evaporators.

The 21 rooms mentioned have a useful area of 4,452 m^2 (47,900 ft^2) and a useful cold storage capacity of 16,600 m^3 (585,000 ft^3) (the gross capacity amounting to 20,202 m^3 or 715,000 ft^3).

Insulation

The complete insulation of rooms, line shafts, control room, equipment and lines is made of fully expanded cork, applied in three layers and stuck together with pitch grout. The thermal conductivity of this cork is 0.029 kcal/m.hr.°C (0.234 Btu.in/ft^2.hr.°F). The cold rooms are designed for temperatures of −30° to −35°C (−22° to −31°F). The thickness of the insulation is 30 cm (11.8 in) for the outer walls and 26 cm (10.2 in) for the inner walls. All rooms are separately insulated. In all 4,881 m^3 (172,000 ft^3) of cork slabs and cork jackets were used in the building.

Refrigerating Equipment

The engine-room on the fifth floor houses eight ammonia compressors catering for the two cold stores "Amerika" and "Australië." Their capacity is 1,500,000 kcal/hr (5,950,000 Btu/hr) at an evaporation temperature of −15°C (5°F), a condensation temperature of +30°C (86°F) and a liquid temperature of +25°C (77°F). There is room available for further units if the cold storage capacity should be expanded in the future, or if lower temperatures should be required. All the condensers are located in the engine-room. The 6 pumps for the supply of cooling water are in the cellar, and cooling water is drawn from the Y. The joint capacity of the pumps is 325 m^3 (71,500 galls) per hour. This capacity may be raised if required. All control valves are concentrated in an insulated room on the fourth floor in which the temperature is kept between 0°C and −10°C (32°F and 14°F) to suppress white frost and minimise the insulation of lines. This insulation prevents condensation of ammonia in the lines for the higher evaporation temperatures. The space contains four batteries of valves by means of which the evaporators can be controlled, shut off or defrosted. Frost on the evaporator coils in the cold rooms is removed by hot ammonia gases.

To remove any entrained oil from the coils, the lowest point of each group of evaporators is connected to a collecting vessel for oil in the pump cellar.

Next to the condensers and close to the liquid separators in the engine-room four gear pumps for liquid ammonia are installed, by which the pressure in the liquid lines can if necessary be increased to facilitate control of the cooling agent circulation. For purging of air from the system a central purging apparatus is fitted which can be connected to each condenser as required.

Cooling operations are carried out at three mutually independent ammonia evaporation temperatures, viz. from −5 to −10, −20 to −25 and finally −35 to −40°C (23 to 14, −4 to −13 and −31 to −40°F). For this purpose three separate line systems were required. For the higher evaporation temperatures three single-acting vertical ammonia compressors of different size are used, so that the capacity can be adapted to requirements. These compressors operate with single expansion and compression.

For the lower evaporation temperatures three compound units are used, which operate with two-stage expansion and compression. For each unit an intermediate cooler is installed on the fourth floor right below the unit. Two of these compound units each have a separate low-pressure and high-pressure compressor with motors. By means of cross connections each of the four compressors of this combination can also serve for the higher evaporation temperature, which increases reliability of performance and facilitates variation in capacity. The third compound unit is a combined one of high capacity, which operates only at the low temperatures. Since each of the six units has its own condenser and cooling water pump the ammonia for each evaporation system is kept apart.

Each cold chamber and each compressor unit can be connected to any line system, i.e. to each of the three evaporation temperatures. Thus the optimum evaporation temperature for a given room can be chosen, in accordance with the temperature desired for the chamber in question. Besides, an automatic back-pressure control valve in the suction line provides additional and highly accurate control of the evaporation temperature for each evaporator in each cold room. For very sensitive products the surface temperature of the cooling coils and the relative humidity can thus be accurately controlled.

All the rooms should be suitable for the storage of frozen goods at temperatures between −20 and −30°C (−4 and −22°F); cooling in each chamber takes place by means of wall coils for direct evaporation. Apart from the connecting lines 48,009 running metres (157,500 ft) of evaporator coils have been installed

Fig. 6. Cold Chamber: coils; note the mushroom construction of the floor and the insulated hatch communicating with the ventilation system (background).

in the building and the cooling area of the evaporators totals 6,336 m² (68,100 ft²).

These temperatures are reached with free convection, i.e. without using forced air circulation. In the five freezing rooms (ground floor, first and second floor), where very low temperatures can be reached, a strong circulation of air is effected by means of powerful fans.

As the ordinary cold rooms will also be used for the storage of goods at higher temperatures up to 0°C (32°F), extra measures had to be taken for these rooms. Against the ceilings on one side of the rooms fans with diffusers are installed, which provide a strong forced circulation of air. With forced circulation part of the wall coils are by-passed, only the coils before which the fans have been mounted being left in operation. Wooden partitions which can easily be mounted then convert them into air coolers. As the evaporation temperature of the ammonia in the coils is in this case adjusted as close as possible to the temperature of the chamber operation at a high relative humidity is permissible. Besides, when cooling fruit, ventilation can take place according to requirements (see next paragraph).

Ventilation

To ensure regular ventilation in the cold rooms an air duct system has been provided, the two main lines of which join on the third floor. These two main lines run to two suction chambers provided with powerful fans, located on the fourth floor.

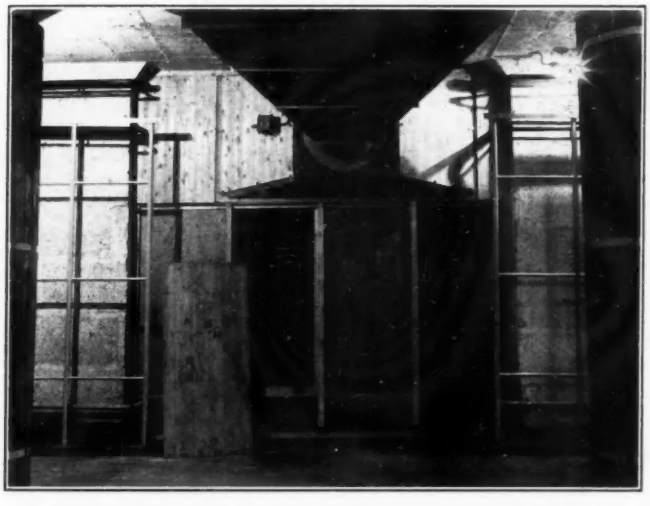


Fig. 7. Fans with diffusers; wooden partitions are used to obtain forced circulation of air at higher temperatures (around 0°C).

Each cold room can be connected to this ventilation system by means of an insulated hatch and the air in these rooms can be replaced within a very short time. The fans are reversible, and can thus be used either for suction or for pressure. By a system of hatches in the two main ducts on the third floor the uncooled loft can also be ventilated. Moreover, the fourth floor contains a defrosting space or service space where sensitive goods which have been chilled or frozen can be rapidly brought to a higher temperature. Condensation can be prevented by strong circulation of conditioned air.

Electric Installation

The main supply and distribution of electricity take place on the ground floor, which accommodates the transformers, the high tension room and the low tension room. Five supply cables pass from the low tension room through the shafts constructed beside two lifts to a central switch cabinet with five panels in the engine-room. This switch cabinet serves the motors of the refrigerating units. Green signal lamps clearly indicate which machines are in use. Red signal lamps light in case of failure. In front of the switch cabinet a deck has been placed for operating each of the fans in each of the cold rooms. The same desk accommodates the equipment for the distant reading thermometer installation, which has three precision measuring instruments for the cold store " Amerika " and a similar instrument for the adjoining old cold store "Australië." In the engine-room selector switches enable the temperature at 43 points in the cold store " Amerika " and at 18 spots in the cold store " Australië " to be read.

SAFETY APPLIANCES

To prevent personnel from being trapped in refrigerators an electric bell warning system was installed. Push-buttons near the doors operate red signal lamps on the engine-room panel, as well as a klaxon. This signal system has its own safety device, because in case of failure of the electric current of the signal system a green lamp in another circuit will indicate this failure. Personnel can leave the engine-room and also the lift engine rooms by using fire-escape ladders if the stair-well at the Y-side cannot be reached. In addition, eight escape-ladders are fitted under the engine-room windows.

An air compressor which keeps a system of dry lines filled with air can in case of fire be switched off immediately by means of cocks connected to these lines; subsequently, a water pump automatically comes into operation and immediately fills a parallel line system with extinguishing water for the whole building. In addition, the building has a dry line system to which the Municipal Fire Brigade can connect its water supply lines from the outside of the building, and its own hoses in the stair-wells on each floor. Twenty portable carbon dioxide extinguishers are ready for immediate use everywhere in the cold store. The building is furthermore protected by a series of lightning conductors.

To ensure a satisfactory check of the performance of the various units the 15 ammonia gauges are conveniently arranged on 3 gauge panels. The oil pressure gauges are fitted on the compressors. All the ammonia gauges are provided with a signal contact with klaxon to sound as soon as the condenser pressure becomes too high. The oil pressure gauge of the large compound unit is also provided with a similar signal system to warn as soon as the oil pressure drops.

As soon as the pressure in the delivery lines of compressors reaches a dangerous level, they are switched off electrically by pressotats. Level controllers, mounted in the intermediate coolers of the compound units, cut out the machines as soon as the liquid ammonia rises to a dangerous level. This prevents hammering in the cylinders, which may cause fracture of the cylinder tops. Moreover, a siren is operated automatically when the machines have been cut out by the level-controllers. All the motors are provided with thermal overload breakers. To increase safety, revolving parts of the engines are provided with wire netting screens; fly-wheels are painted in red and surrounded by railings of glaring yellow colour.

Gauge-glasses on the condensers and machinery and portable electric hand-lights are electrically lighted by current at only 24 volts.

Particular care is bestowed on the protection against gases. The main switch-board is fully gas-tight; in places where explosive gas-mixtures may collect the electric sockets for connection to the mains are explosion-proof. The lines carrying ammonia (either liquid or gaseous) within the cold chambers are protected against damage from impact by means of wooden screens or stakes. An oxygen respirator ready for immediate use is within easy reach. Two fans having a joint capacity of 50,000 m³ per hour (29,400 ft³/min) remove any gases and vapours. The balconies are surrounded by strong railings and a raised concrete edge serves as a wheel-buffer for transport equipment (electric vehicles). Good lighting permits safe work on the balconies in the evening and at night. The large metal overhead doors, which can be operated by one person, are provided with a safety device which causes a steel pin to block the door if a wire rope of the balancing weights should break.

The electric transport equipment is fitted with a device which prevents its being started unless the driver is occupying his seat behind the wheel.

New Vehicle and Passenger Ferry

A new 671-ton diesel twin screw vehicle and passenger ferry the 'Carisbrooke Castle' entered service between Southampton and Cowes at the end of May. Operated by the Southampton, Isle of Wight and South of England Royal Mail Steam Packet Co., (Red Funnel Steamers), the vessel was designed and built by John I. Thornycroft & Co., Ltd., Southampton.

This latest addition to the Red Funnel fleet has been designed to meet present-day requirements of traffic to and from the Isle of Wight, in particular, the heavy demand for the transport of motor vehicles. In addition to motor cars, all types of commercial vehicles including loaded lorries, mobile cranes and heavy outsized vehicles can be carried. Conveyed on a 'Roll-on'—'Roll-off' principle, sailings are so timed that it is possible to effect deliveries in the Island and return to the mainland in one day, thus avoiding the necessity of double or treble handling and the possibility of losses and breakages. Altogether about 45 vehicles can be carried on the main deck with unrestricted height at the fore-end for lorries of up to 20-tons each.

Loading is carried out by an articulated ramp at the extreme fore-end of the ship. Side loading is also provided for with ship-side sliding doors giving access to the sheltered car deck, whilst hinged bulwark doors forward provide access for larger vehicles. A 13-ft. diameter turntable is fitted flush into the after-end of the car deck to assist in the stowage of vehicles.

When required, the ferry can be used for passenger service only and is then capable of carrying 1,200 people.

Passenger accommodation includes a large observation lounge and saloon on the promenade deck which is equipped with a buffet bar and extra large windows. Bright colours and furnishings of a contemporary nature have been used throughout. A large number of deck seats are arranged on the promenade and boat decks. Seating on the promenade deck is protected from the weather by glass windows at the side openings.

The deck machinery, supplied by Vickers Armstrong (Engineers) Ltd., consists of one cable lifting and warping capstan (starboard) and one warping capstan (port), both fitted forward; two ramp hoisting winches placed in machinery houses (port and starboard) forward and one warping capstan fitted aft. The steering gear is hand and power electric hydraulic type, the motor, rams and pump being positioned in the steering compartment coupled to twin spade type rudders, the bridge control being by telemotor gear.

The main propelling machinery, has been supplied by Messrs. Crossley Brothers Ltd., and consists of two 8 cylinder direct reversing marine diesel engines giving a service speed of 14 knots

Solid rubber side fenders supplied by Firestone Tyre & Rubber Co. Ltd., in steel housings are fitted over the entire length of the vessel. Two 16 ft. lifeboats mounted in high-level davits are fitted on the boat deck, and all exposed passenger decks are covered with $\frac{3}{8}$ in. thick deck composition.

M.V. "Carisbrooke Castle".

Electric power at 220 volts D.C. is provided normally by three 50 kW diesel auxiliary generators. As certain services are required to run throughout the night, a 5 kW motor generator is fitted to operate from a shore supply. This supply differs at the two terminal ports, being 415 volts 3-phase at Southampton and 480 volts single-phase at Cowes and a transformer is therefore incorporated in the motor generator set, so that it may run from either.

A public address system for the passengers and crew, is installed with separate loudspeakers for mooring orders. A sound powered telephone provides communication between the wheelhouse and engine room, and a Pye "Ranger" V.H.F. is fitted to work in conjunction with the port information service.

A steamboat service between Southampton and the Isle of Wight was first introduced in 1823. Today the passenger fleet is now composed entirely of modern diesel-engined ships, all equipped to carry vehicles. Regular services for passengers and motor vehicles are operated throughout the year. It is intended that the "Carisbrooke Castle" wil play an important part in speeding up the flow of traffic betweeen the mainland and the island, particularly during the summer season.

View of car ramp in down position.

Salvage of the Dredge "Hapai"

Description of Operation in Auckland Harbour *

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Introduction

DURING a north-easterly gale, in the early morning hours of Monday, June 24, 1957, the Auckland Harbour Board's bucket dredge "Hapai" overturned and sank in the Rangitoto Channel, in about 26-ft. of water.

The "Hapai" had been dredging sand about three-quarters of a mile offshore for the placing of a sand mattress in connection with the construction of a new wharf. The crew had left the dredge, moored for the weekend, at midday on Saturday, with a caretaker on board, a partially loaded 450 cu. yd. hopper barge moored alongside to starboard, and a half-full 100 cu. yd. hopper barge on the port side.

The "Hapai's" crew left Auckland at 7 a.m. for their day's work and discovered the sunken dredge in the early morning light. The watchman was found clinging to the hull. The small barge was still held one end, by the mooring lines, but the larger barge had broken adrift, and was taken in tow later in the morning.

The dredge was lying on her starboard bulwarks and the top of her tower, the bottom of the ship being at an angle of 30° to the vertical. The bulwarks were resting on the harbour bed from the stern to amidships, but from here to the bow the dredge was unsupported. The "Hapai" had capsized into the cut she had dredged previously. The bulwarks were resting on the un-dredged bottom at 26-ft. below L.W.S.T. while the tower had fallen into the cut 5-ft. deeper. The weight supported by the tower amounted to 350 tons, and this heavy load broke one of the large bucket drive gear wheels.

Particulars of the Dredge

The dimensions and tonnage of the dredge are as follows:

Length: B.P. 205-ft., overall 210-ft. 9-in.
Breadth moulded: 40-ft.
Depth moulded: 14-ft. 9-in.
Tonnage, gross: 870 tons.
Working draught: Empty—fore, 9-ft.; aft, 11-ft. 6-in.
Loaded—fore, 11-ft. 6-in.; aft, 13-ft. 6-in.

Working displacement empty, approximately 1,400 tons. Two engines triple expansion, condensing, of 400 h.p. each. Two multi-tube oil burning marine boilers. Buckets 1 cu. yd. capacity, normal speed 12 per minute. Weight of tumblers, buckets and ladder complete, approximately 150 tons.

Built by Fleming and Ferguson at Glasgow in 1908.

Major overhaul during 1955 when new bucket ladder complete with buckets was fitted and boilers adapted for oil burning.

Method of Righting

The Auckland Harbour Board decided to obtain the services of a salvage expert. On July 6, Captain J. N. Edwards, Chief Salvage Officer for the Port of London Authority, arrived.

Prior to Captain Edwards' arrival, a scheme for righting the dredge had been prepared, and after some discussion, the method was approved and the Board gave the word to proceed with the salvage.

It was calculated that a maximum moment of 28,800 foot-tons would be required to right the dredge. This moment was a maximum at the commencement of movement, decreasing as the dredge rolled on to her side, then increasing again to roll the dredge over her bilge, and again decreasing till the dredge finally fell under her own weight.

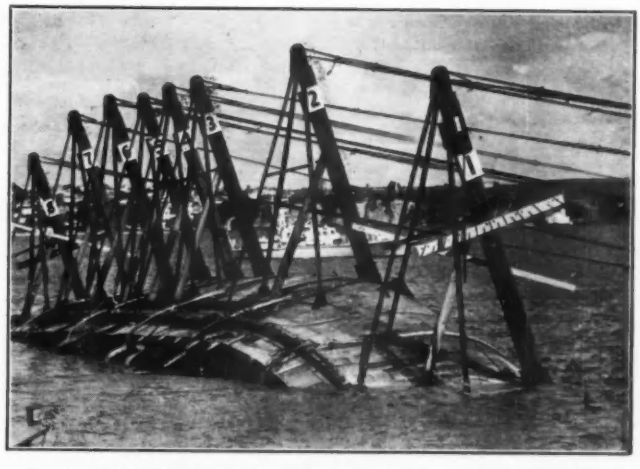


Fig. 1. Eight frames 20-ft. high in position on the hull, pull of 320 tons causing initial rotation.

To obtain this moment it was decided to use eight frames 20-ft. high erected on the side of the dredge. A force of 60 tons at the top of each frame then gave the required moment, and was adopted as the nominal load for the design of frames, anchors and pulling gear.

Righting Frame

The construction of the righting frame can be seen in Fig. 1. The forces transferred from the frames to the dredge amounted to some 120 tons from the strut at the start of movement and 120 tons in the tie when the dredge was rolled over her bilge. These loads gave very low local stresses in the hull when spread to three hull frames beneath the strut or to the deck, which acted like a deep girder for the tie. This check was confirmed when a load of 77 tons was applied to frame No. 1, during the righting, producing a downward force of 135 tons on the hull. No sign of buckling was apparent.

The struts were made of hardwood as this was readily available from stock. The base of the timber strut was housed in a steel chair which spread the load over three hull frames. To take

*Paper (slightly abridged) presented at the 1959 Conference of the New Zealand Institution of Engineers.

the tensile load, the 12-in. x 1-in. steel tie from the head of the frame was bolted to the deck and 5-in. x ½-in. side braces were provided to take the deviation of pull of 10° should the ship slew during the operation.

To obtain a joint to transfer a force of 120 tons on to the deck, great care was taken in bolting the 12-in. x 1-in. steel ties. Rivets were blown out, then drilled and reamed with the tie plate in place. A hole was cut in the deck to enable the high tensile bolts to be placed and the nuts were tightened with an air impact wrench. This work was perhaps the most difficult of any and could be carried out only at low tide, and for those near the bow and stern, at low spring tides.

Tackle

To provide the 60-ton pull to each frame, sixteen heavy sheave blocks were purchased from a local shipping company. Regardless of the number of sheaves, all blocks were reeved with 3⅛-in. wire to give an eleven-fold purchase with equal pulling speeds.

During the rolling-over movement, the length of arc covered by the top of the frames, from the initial position to the point where movement continued under gravity alone, was 72-ft. A length between blocks of 120-ft. was provided to allow for any sliding or slewing. The pennants connecting the blocks to the frames and the anchorage were made up of several parts of 3-in. or 4-in. wires to give a factor of safety of 2, that is, a breaking load of 120 tons. So that individual wires would render and carry an equal load, 7-in. diameter pins were provided at all end fixings. The pennants were made up on shore and the wires held in place with light mild steel straps.

Anchors

From soundings, bottom samples, dredging and prickings, it was known that the harbour bottom was a fine sand with many large and small shells, with layers of fine sand and silt one to three feet thick on or near the surface. A firm layer existed about 15-ft. below the surface and the piles usually pulled up at this depth. The anchors were designed for normal working stresses in the timber piles and values of $\phi = 35°$ and W=56 with a factor of safety of 2 for movement against passive soil pressure. To obtain the maximum soil resistance, the piles were arranged in a line, at right angles to the direction of pulling. The anchor for each frame was a separate unit and consisted of 3 rows of piles 100-ft. apart, the front row of 12 piles being tied back at half tide level to an R.S.J. laid on the harbour bed behind the next row of six piles, the heads of which were in turn tied back to two piles. This system is, in fact, a large version of an army picket anchorage. A broad flanged beam was laid behind the front row of piles and connected to the pulling gear through a gap in the centre of the row.

Each anchor consisted, therefore, of twenty piles, so some 160 piles were driven in the main anchorage.

Two similar sets of 20-pile anchors were driven on the far side of the "Hapai." These were anchors for the parbuckle holding wires which prevented the "Hapai" sliding along the bottom, or slewing, during the righting operation.

Winches

The arrangement consisted of two new Navy double drum diesel winches with a hydraulic coupling and a total pull of 10 tons each mounted in two lighters moored ahead of the main anchorage, and two similar steam winches on the minesweepers H.M.N.Z.S. "Stawell" and "Echuca" which were moored on dolphins behind the main anchorage.

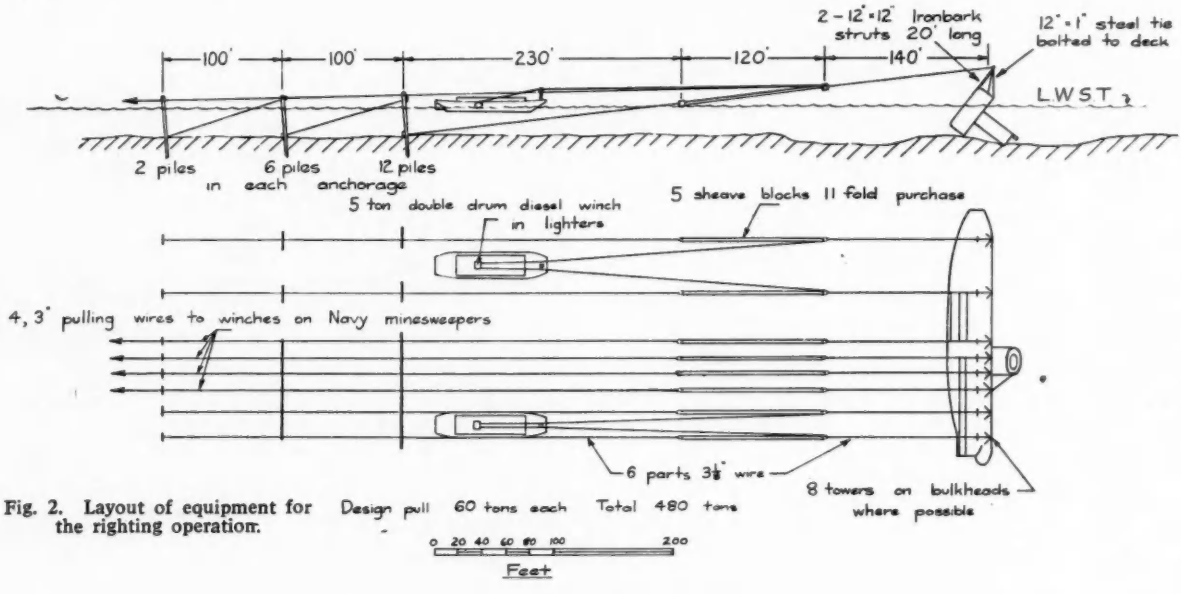


Fig. 2. Layout of equipment for the righting operation.

These circular dolphins consisted of nine perpendicular piles and in addition three-pile anchors were driven off the bow of each minesweeper to take the 10-ton winch pull. The layout of gear for this operation is indicated in Fig. 2.

To measure the loads on the eight tackles a simple wire load gauge was positioned on the hauling wires ahead of each winch drum. The gauges were calibrated from 2 to 7 tons and worked well with an accuracy of about ½ ton on stationary and moving wires. They were the means of keeping the load spread evenly on the four double drum winches. Without these gauges it would have been possible to overload one tackle with perhaps, disastrous results.

Soundings showed the dredge was in such a position that, when righted, it would have listed 5° to 10° into a previous cut. Approximately 1,000 cu. yd. of sand were dumped into this hollow to build up a level bed, and measurements taken after righting showed that the final list was less than 1° to port with the keel at the bow about 1-ft. higher than the keel at the stern.

A platform 8-ft. high from which the operation was controlled

was built on a punt and moored off the bow of the "Hapai." R/T sets were used to convey all orders and messages to and from the winches, with Navy semaphore signalmen on hand in case of breakdown. Flag signals were used to co-ordinate all winch operations and provide a visual indication of the load conditions at any time.

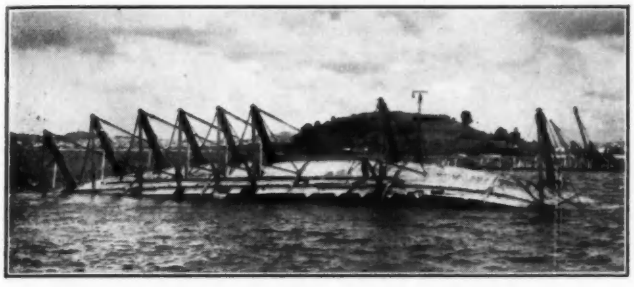


Fig. 3. Eight frames and pulling wire in position. Some of 160 piles in the main anchorage visible behind.

The Operation

On Monday, September 30, the two Navy minesweepers "Stawell" and "Echuca" were brought into position. A test was carried out using the "Echuca's" winches and a load of 4 tons on each of the two hauling wires was obtained and held simultaneously.

The next morning, October 1, the lighters were towed in and moored in position.

A short summary of the record of events follows:

Time: 12.23: Pulled up to 3 tons per winch (total pull—240 tons).
12.58: Pulled up to 4 tons per winch (total pull—320 tons).
13.08: Pulled up to 4½ tons and tried to maintain. Movement commenced (total pull—360 tons).
13.15-13.20: Stopped pulling to even up wire tensions.
13.21-13.32: Rotated through 35° to bottom vertical.
13.32-13.40: Evened up wire tensions and pulled up to 4½ tons (total pull—360 tons).
13.40-13.49: Rotated through 90°, last 35° by gravity.

Fig. 4 shows the pull required during the rolling over.

Method of Lifting

The following methods were considered: Cofferdam, hopper barges, lighters, deck cofferdams, jack-off piles, and camels (the adopted method).

Cofferdam

In this scheme, it would be necessary to build a double-walled or cellular steel sheet pile cofferdam to surround the "Hapai" completely and to withstand pressures due to a difference in water level of 38-ft. When pumped dry, it would be possible to make any necessary repairs, and then float the ship with a controlled inflow of water. This scheme was not accepted owing to the time necessary to obtain the materials and build the cofferdam and because of the high cost, estimated at £300,000.

Hopper Barges

The two hopper barges used by the "Hapai" would lift, with sealed doors, a total of 1,400 tons approximately. This would be sufficient total lift, but the difficulty was to position the barges over the "Hapai" and attach wires in a suitable manner for lifting. If all gear was removed down to the "Hapai's" deck level by divers, a sufficient lift could have been obtained to place the ship in dock. The scheme was not accepted owing to the tedious and difficult work necessary by divers.

Lighters

Twelve cargo lighters 90-ft. long by 22-ft. beam were available. Consideration was given to lifting over the bows of the lighters, so enabling a direct lift at several points along the sides of the "Hapai" to be obtained. A lift of 20 tons could be supplied by each lighter, and this lift could be increased to 60 tons, if the after crew compartment was filled with water. The scheme was not accepted owing to the uncertain stability of the lighters with a load over the bow, and because a lift of only 5 or 6-ft. could be obtained on each tide.

Deck Cofferdams

A conventional method of raising a sunken ship, is to seal all small openings, and building cofferdams from one or two of the larger openings to above high water level. The hull can then be pumped out through these cofferdams until sufficient buoyancy is obtained to raise the ship to the surface. This scheme was not adopted owing to the large amount of diver time required, and the uncertain stability of the ship when buoyant, with free water inside.

Jack-off Piles

A unique suggestion was put forward to drive piles at various points around the hull and then, using 100 ton jacks, lift the ship inches at a time, taking the weight on to the piles, until the deck was above water level. The scheme was not accepted owing to the unorthodox method and the difficulty of finding sufficient jacks.

Camels

In this scheme, cylindrical pontoons were constructed to give sufficient buoyancy to lift and move the "Hapai" to shallower water, when, with the deck above water level, the hull could be pumped out and the ship refloated. The diameter of the camels was determined by the buoyancy required to be spaced out along both sides of the ship. The displacement of the "Hapai" is approximately 1,400 tons and the submerged weight 1,150 tons. After some consideration, the dimensions decided upon were: 12 camels, 17-ft. diameter, 24-ft. long, weight 18 tons, 138 tons net buoyancy each, 1,656 tons total net buoyancy.

It was considered by some that the heavy bucket line, bucket ladder and tumbler gear should be removed before any attempt

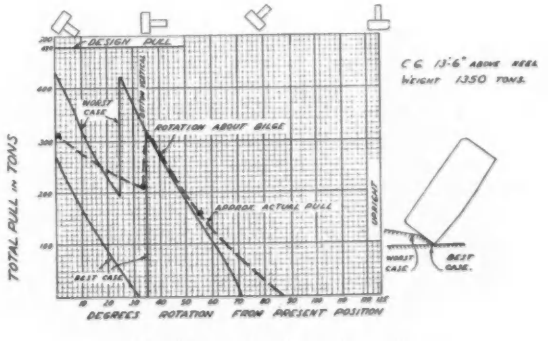


Fig. 4. Graph of rotation/pull.

was made to refloat the dredge. The total weight to be removed amounted to about 150 tons, and this would have the effect of lowering the centre of gravity from 14-ft. to 11-ft. 9-in. above the keel. As this would not have improved to any great extent the good stability provided by the camels, it was decided to lift the dredge as she stood.

Camel Design

The pressures acting on the walls of the submerged camel under load were calculated and an additional 5 lb./sq. in. added as a contingency. The resultant pressure is independent of depth. Ring girders were provided at 4-ft. centres, and bending moments in these were calculated by the column analogy, 4-in. x 3-in. R.S.J.'s being sufficient.

Shell thickness was calculated from stresses due to circumferential, longitudinal and bending tensile forces, these being 2,080 lb./sq. in., 2,080 lb./sq. in. and 4,160 lb./sq. in. respectively for $\frac{1}{4}$-in. plate. This plate thickness was considered to be the smallest desirable to withstand subsequent handling and local loading. The shell was also checked for crinkling through bending as a beam by a formula from Conway's "Aircraft Strength of Materials."

The load on the flat ends of the camel was taken by

(a) 3 pairs of boiler stay tubes extending end to end.
(b) 3 vertical internal 10-in. x 5-in. R.S.J.'s.
(c) 7 horizontal external 4-in. x 3-in. R.S.J. stringers at centres, varying from 1-ft. 9-in. at the top to 2-ft. 6-in. at the bottom. Plate thickness was calculated to be 5/16-in. from Crashof's, Pounders, Bach's and Timoshenko's formulae.

It was originally intended for simplicity and cheapness to construct the camels as simple cylinders. However, it was shown that this shape is unstable longitudinally when partically filled with water, and a central bulkhead was provided giving two completely separate compartments. The central bulkhead was of similar construction to the ends. The weight of each camel was 18 tons approximately, including over $\frac{1}{2}$ ton of ballast.

Towers consisting of two 10-in. x 3-in. channels with a central 10-in. x 6-in. R.S.J. and extending 4-ft. above the camel were constructed at each end to enable the fixing of lifting wires to be carried out above water level at low tide.

The lifting wires were led around a fairlead at the centre of each end of the camel. Thus the towers could be maintained vertical (or at any required angle) without imparting a rotational force to the camel.

Buffers were provided at each end to keep the thin shell away from the hull and to transfer all the heavy loads through the ends. The buffer width was 12-in., 18-in. or 24-in. depending upon the curve of the belting of the "Hapai" in the vicinity.

Calculations for the size of valves were based on the use of one 250 cu.ft./min. compressor per pair of camels. This required a 6-in. water valve at the bottom of each compartment and a 1-in. inlet valve and air hose. With this arrangement a pair of camels could be blown out to full buoyancy without undue pressure drop through the 6-in. valve, in about 40 minutes. Finally, $\frac{3}{4}$-in. hose was used for the central eight camels, and an extra 1-in. valve was fitted to each camel compartment to prevent air locking. Safety valves were included and these could be opened when faster sinking was desired.

Air Supply

To enable full buoyancy to be obtained in less than 1 hour, a total of 6 compressors with capacities from 155 cu.ft./min. to 250 cu.ft./min. were accommodated in a cargo lighter moored alongside but held clear of the camels, by two piles fitted each end with rubber buffers, and hung horizontally between the "Hapai" and the lighter. Individual 1-in. hose led from each compressor to the control device called "the organ," situated on a temporary bridge constructed on the "Hapai's" upper works well above water level. From a common 3-in. pipe manifold, 15-ft. long, blowing and venting valves and 0-15 lb./sq. in. pressure gauges, were arranged to allow the control and measurement of buoyancy in all 24 compartments of the camels. From a measurement of the camel freeboard or submergence, together with the internal air pressure, the buoyancy to the nearest ton could be obtained from a table. The internal air pressure could be read only when blowing or venting was stopped.

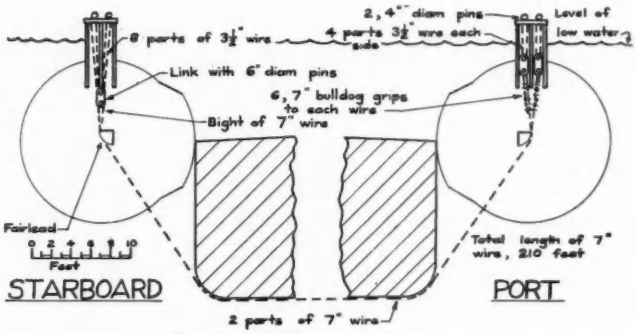

2, 4" diam pins
Level of low water
8 parts of 3½" wire
4 parts 3½" wire each side
Link with 6" diam pins
6, 7" bulldog grips to each wire
Bight of 7" wire
Fairlead
0 2 4 6 8 10
Feet
Total length of 7" wire, 210 feet
STARBOARD
PORT
2 parts of 7" wire

Fig. 5. Attachment of camels.

Attachment of Camels

The largest wire available in New Zealand in sufficient quantity was 7-in. circumference 6/37 galvanised wire. This was cut into lengths of about 230-ft. to pass, doubled, around the hull of the "Hapai" opposite each end of each camel. Before the dredge was righted, the ends of the wires were coiled as far under the ship's side as possible, and the wire laid around the upturned hull. After rolling over, both ends were then available.

Perhaps the most vexing problem of all, was how to fix the 7-in. wires to the camels (Fig. 5). A tapered stopper was designed but the total cost of local manufacture for 48 off was in the vicinity of £10,000. Carpenter stoppers for 7-in. wire rope were available in England at a cost of £420 each. Finally conventional dog clips were made in aluminium bronze, 5 of these withstanding the test load of 70 tons.

A doubled 7-in. wire was provided for each end of each camel, the bight being on the starboard side and the two loose ends being on the port side of the ship. The loose ends were turned and clipped off with the dog clips to give the correct length of wire. The loops were then placed around one pin of a large link and several parts of 3½-in. wire rope taken from the other pin of the large link to two 6-in. diameter pins bolted to the top of the camel tower. A breaking strength of 260 tons was then available at each end of each camel against a maximum working load of 100 tons. The pair of camels was then evened up to the correct height with the assistance of a floating crane on each side, and a full buoyancy test carried out. The friction of the wire against the hull was relied upon completely, to prevent rendering, and it was necessary, during the test and subsequently, to ensure as near as possible, the same buoyancy in each camel of the pair. The camel turned out to be a temperamental creature, and it took several days to learn how to keep them in hand. On one occasion, a camel moved astern under load, bent the buffer and opened up a few small holes, requiring major surgery.

The arrangement of the camels around the hull is shown in Fig. 6.

Anchorages

To prevent the dredge from floating up harbour on the incoming tide, anchorages were driven about 1,100-ft. from the bow, forming the centre of an arc along which movement inshore to shallower water took place. Two such movements were carried out. The anchorages consisted of two 14-in. x 12-in. B.F.B.'s 45-ft. long driven 100-ft. apart into the sandstone bottom. A

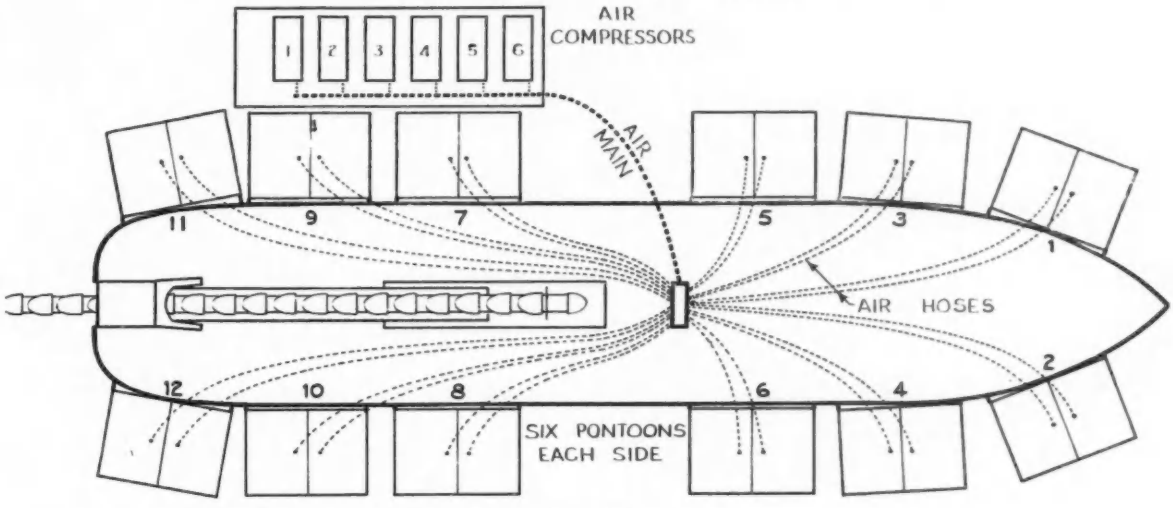


Fig. 6. Arrangement of camels around hull.

wire passed from the top of the forward pile to the rear pile at sand level. Two 4-in. wires formed the 1,100-ft. long pennant from the anchorage to the "Hapai's" bow.

The First Lift (March 1, 1958)

The previous day, the camels had been left in position with about half maximum buoyancy. Blowing of the camels commenced at 9.05 a.m. and the bow rose about 2-ft. at 9.35 a.m. when the total buoyancy was 1,014 tons. Blowing was continued on the camels near the stern and at 10.19 a.m. the stern rose about 4-ft. The "Hapai" was then towed inshore by four small tug boats as the tide rose, just touching the bottom all the way. Approximately 3½ hours later, when she was in the planned position, the camels were vented. She was then in 18-ft. 6-in. of water (below L.W.S.T.) a vertical lift of 8-ft. having been obtained.

The Second Lift (March 26, 1959)

The portion of the dredge now showing above water was hosed down with a water jet supplied through a fire hose and nozzle from a 3-stage diesel-driven pump. An extension piece 4-ft. high for the camel towers had been fabricated, and these were bolted to the towers along the port side with the camels resting on the bottom. The 7-in. wires were pulled through under the hull and re-clipped to the tower extensions. By this means, all work could be done above low water level.

At the first light of dawn on March 26 blowing was commenced on all camels. After a lift of about 2-ft. at the bow, the camels on the port side reached sufficient buoyancy to come to the surface and produce a list to starboard of 8°. With blowing continuing on the starboard side, 20 minutes later a movement took place resulting in a list of 8° to port. These movements were anticipated by those planning the operation, but caused great anxiety to others watching. Finally, at 6.40 a.m., the "Hapai" reached an even keel and began to be towed inshore on the rising tide. To reduce the draught further at the stern, the two after chain lockers were pumped out, and the "Hapai" settled in the planned position at 9.48 a.m. The decks which were covered with 2-in. to 3-in. of silt were hosed down during the next few days. A vertical lift of 9-ft. 6-in. had been obtained leaving the decks a little below half-tide level.

Pumping Out and Floating

The eight central camels were left in position with about 50 tons buoyancy in each as it was feared that the ship might take an unhealthy list if some free water still remained in the bilges. With the camels in position, it was possible from their buoyancy readings to anticipate any list. The camel buoyancies on the two previous moves inshore had shown a difference of about 60 tons between the port and starboard sides. Water was now left in the "Hapai's" port buoyancy tank and this corrected the list that otherwise would have resulted.

A comprehensive lighting system was installed to provide sufficient light to work the pumps before dawn, and to light the inside spaces after the bulk of water had been pumped out.

At 5.45 a.m. on March 31, pumps totalling 7,000 gal./min. capacity were placed aboard as the tide ran off the decks, and pumping out commenced. By 7.30 a.m. most of the water had been removed, and work was continued with air pumps to remove the last few inches of water in the bilges. At 10.30 a.m. the "Hapai" was just afloat without showing any list, and the camels were gradually vented. By 3 p.m. the camels were on the bottom, and the "Hapai" was once more buoyant. Much discussion had previously taken place as to whether the camels should be completely removed from the area, but it was decided to attempt to pull the dredge clear of the camels and lifting wires, with tugs. Initial pulling showed that the dredge was held by the 7-in. wires which were caught on underwater projections from the hull. The 7-in. wires were cut and fell to the bottom. Finally at

Fig. 7 View of salvaged dredge surrounded by the "camels" used to lift and move it to shallower waters in Auckland Harbour.

Salvage of the Dredge "Hapai"—continued

6 p.m., under the combined pull of the two Board's tugs together with three smaller tug boats, the "Hapai" came clear and was towed to her berth.

Costs and Economics

The 49-year-old dredge had undergone a major overhaul two years previously and the book value stood at £150,000. A considerable amount of new gear had been added and she was in quite good working condition. When the Board considererd the future of the sunken dredge, there were three courses open:

(a) Leave the dredge where she lay. This, they decided, could not be tolerated mainly for aesthetic reasons.

(b) Break up by explosives placed by divers and remove piece by piece. This method was sometimes used during and after the war in English ports, but proved to be an expensive procedure. In the case of the "Empress of Canada" which capsized in the Liverpool Docks after an outbreak of fire, it was considered cheaper to roll her over, refloat, prior to handing her over to the shipbreakers, than to cut her up where she lay. Within a day or two of the "Hapai's" capsize, a bucket dredge similar to the "Hapai" capsized in an Australian port and was broken up and removed as she lay. As far as can be ascertained the cost of breaking up this dredge will prove to be of the same order as the cost of righting, refloating and docking the "Hapai."

(c) Salvage and refit. This has proved to be the wisest decision from almost all points of view. A new dredge of the same type as the "Hapai" would cost today something like £750,000 with a three-year delay before delivery.

The cost of the salvage operations was in the vicinity of £110,000 and the cost of cleaning and refitting amounted to about £50,000. The refitting progressed satisfactorily, and the dredge was working again by October, 1958. Although most of the working parts of the dredge had lain under water for nine months, the work necessary has entailed little more than that required for a major overhaul.

Cause of Capsize

A Court of Inquiry set up by the Marine Department of New Zealand has found that the capsizing of the dredge was due to entry of seas through an insecured porthole.

Wales and Its Sea-Board

By SIR MILES THOMAS, D.F.C.
(Chairman of the Development Corporation for Wales)

In recent months industrialists in Britain, Canada, U.S.A. and other countries throughout the world have been told in many ways of the industrial opportunities that abound in Wales. They have heard about the industrial wealth of Wales, the admirable sites that await development, the efficient and responsive labour force and numerous other attractions and advantages that are available in Wales to-day to the enterprising industrialists.

There is no doubt that the industrial future of Wales is indeed bright and the several ambitious projects now under way are pointers to others which are certain to follow in the years to come.

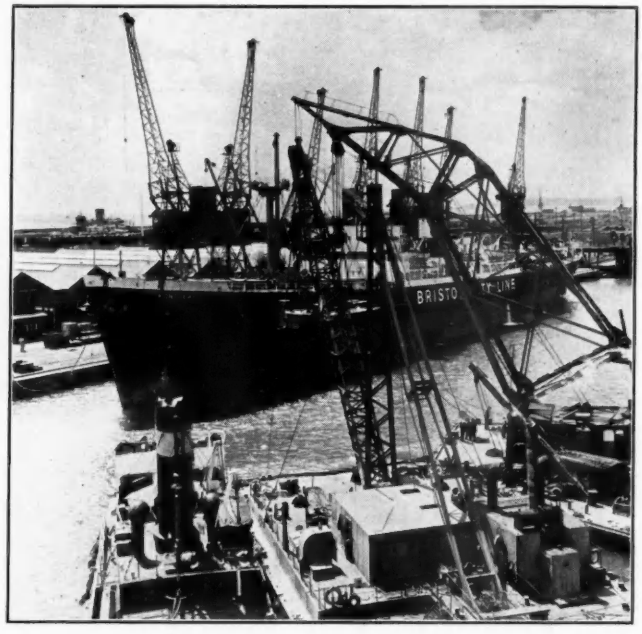
One aspect with which we as a Development Corporation are concerned, and which is of particular interest to readers of " The Dock and Harbour Authority," is sea-transport, which has played such a prominent part in the economic life of Wales and Britain.

The changing pattern of the industrial structure in Wales has had a direct bearing on the fortunes of its ports, and consequently, the post-war period has been one of re-adjustment and re-equipment. Since its inception the British Transport Commission has authorised well over £6 million for schemes of major improvements and modernisation for the South Wales Docks.

These ports range along sixty miles of the Welsh coast of the Bristol Channel and the principal ones are Cardiff, Newport, Barry, Port Talbot and Swansea. They have a combined enclosed dock water area of 704 acres, with 23 miles of quays.

Each port is directly connected with the main line railways of the country and each has its own internal road system. There are excellent facilities for all kinds of traffic, including electric quayside cranes, floating cranes and spacious transit sheds—all of which contribute to the quick turn-round of vessels using the South Wales Docks.

There are also fork-lift trucks and mobile cranes for use in transit sheds, in ships' holds and on the quayside; calfdozers for use on bulk cargoes in ships' holds; electric trucks, escalators, etc. For the shipment of coal there are a number of coaling appliances at each port which load vessels very expeditiously.



A recent shipment of two steel mill housings at Swansea Docks called for the joint use of the 100-ton and one of the 50-ton floating cranes.

Recent and Future Improvements

Newport and Port Talbot have been equipped with new bulk discharging berths, and another is in an advanced stage of construction at Barry. At Newport, there are two such berths, each with a battery of five 10-ton modern electric cranes. The bulk cargo berth at Port Talbot has a battery of four similar cranes, and the berth at Barry will be equipped with five 10-tonners.

Expenditure has recently been authorised for the replacement of hydraulic cranes at Swansea by four new 10-ton, and five new 7½/4-ton, electric cranes, the repaving of the quayside and the provision of additional adjacent railway facilities. Other improvements at this port include the replacement of the approach jetty to the main Entrance Lock (now virtually completed), the building of a new impounding station, the complete reconstruction of a wharf, and the replacement of two coal hoists.

At Newport, two transit sheds are included in a scheme of improvements, together with the provision of twenty new 6/3-ton electric cranes. One of the sheds, measuring 600-ft. by 100-ft., is nearing completion and a start has been made on the delivery and erection of some of the new cranes. Another feature of the improvements at this port is the re-alignment of the dock

roadway which will facilitate the passage of road traffic to and from the South Quay.

Complete dieselisation of railway locomotive stock has been effected at Cardiff Docks and work is nearing completion on the modernisation of the Power Station near the main Lock Entrance by the provision of electrically operated pumps.

Apart from two new tugs purchased a few years ago, a further two tugs, one diesel operated, the other diesel/electric, are now on order for delivery by the end of the year, and these will augment the existing fleets of tugs at the eastern ports of Newport, Cardiff and Barry. The dredging fleet at South Wales is being improved by the construction of two new diesel grab dredgers which will take the place of some of the existing craft.

At all the ports, schemes of electrification have been taking place throughout the post-war years and most of these have either been completed or are in the last stages of completion.

Apart from improvements by the British Transport Commission, other firms, with interests at the Docks, have contributed towards the modernisation of the South Wales Docks, the most notable of which are:—

The construction of a new drydock at Swansea by the Prince of Wales Dry Dock Company.

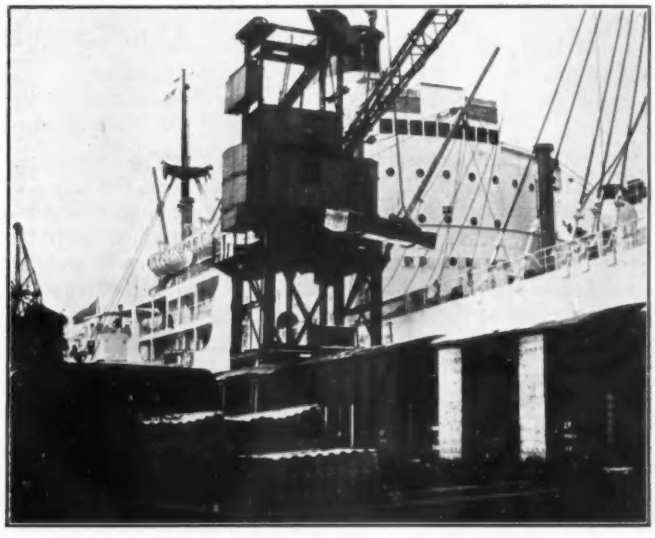
Five new 10-ton "Kangaroo" cranes at Cardiff by Messrs. Guest Keen Iron & Steel Company.

The construction of an Oil Tank Farm and oil discharging berth at Newport by Shell-Mex & B.P. Ltd.

The establishment of a Shipbuilding Yard at Newport by the Atlantic Shipbuilding Company.

Improved iron ore discharging facilities at Port Talbot by the Steel Company of Wales.

The need to encourage trade between the Midlands and the South Wales Ports has during recent years become a significant feature in the economic development of Wales. Hitherto, one of the main deterrents to increasing this trade has been the anomalous position of these Ports vis-à-vis other United Kingdom ports with regard to railway rates. These rates were imposed in the first place to meet the competition of canals and road vehicles and also, to some extent, the competition between the individual railway companies before nationalisation. During recent years, however, they have operated greatly to the disadvantage of the South Wales Ports, when compared with the rates operating at Liverpool, for instance. It is therefore encouraging that this handicap has been removed and that on May 1st last British Railways introduced a system of new rates for import and export traffics (with certain exceptions) through the South Wales Ports.



Direct shipment of tinplate and galvanised sheets ex rail and road vehicles at Newport Docks, per "City of Colombo" bound for East Africa.

The practical effect of this arrangement will be that on qualifying rail borne traffic, dock labour charges for consignments passing through dock sheds will be substantially reduced and no dock labour charges will be incurred when traffic is handled direct from or to ship.

It is hoped that the new scheme of rates will result in additional traffics for the South Wales Ports.

The disadvantage under which the South Wales Ports competed for railborne traffic having thus been removed, the next major step in the endeavours to make the Ports fully competitive is to induce all Liner Companies to accept a proportion of the F.O.B. charges on shipment traffic. This practice of the division of charges as between Shipper and Shipowner, which already operates at certain other United Kingdom Ports, is essential to the full development of the general export trade of the South Wales Ports. Some success has already been achieved, and a number of Liner Companies now bear certain of the shore charges at South Wales.

It is evident, therefore, that determined efforts are being made to ensure that the South Wales Docks will keep abreast with current industrial and economic developments so that they can cope effectively with every demand made upon them.

Large areas of land are available for the establishment of new industries within the dock estates. Some of these are adjacent to deep water berths and the economic advantages offered by such location to industries having good import/export potential is self evident.

All sites can be readily served with electricity, gas and water; and have excellent rail and road connections with main line and trunk roads respectively.

Another encouraging feature is the priority which is being given to the improvement of road communications especially the direct link between the Midlands and South Wales. This will provide a twin gateway from the Midlands into South Wales, one heading for Newport and the other into South West Wales via the Heads of the Valleys road.

This should provide a great stimulus to Midlands' manufacturers to increase substantially their traffic through the South Wales Docks and there is no doubt that all these developments will open a new era for these ports.

Discharge of meat cargo ex "Otaio" to King's Wharf Cold Store, Queen Alexandra Dock, Cardiff.

Port of Hull Reconstruction Works

Riverside Quay and South Side, Albert Dock

(Specially Contributed)

The port of Hull, with docks and works covering seven miles of the Humber river front, has long been amongst the principal ports of the country for value of trade in foreign imports, exports and re-exports. Over 8,000,000 tons of import and export traffic, foreign and coastwise, passed through Hull last year and the value of its overseas commerce was £382,000,000 so that it ranked third in the United Kingdom after London and Liverpool.

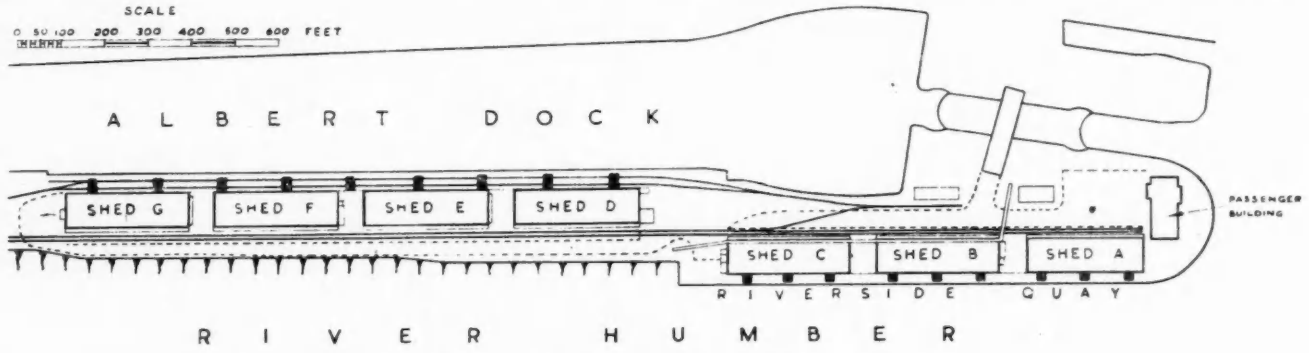
In the port of Hull, the British Transport Commission provide an enclosed dock water area of 200 acres with 12 miles of quays and 320 miles of dock railways. There are two tidal riverside quays and in addition two deep-water jetties (a third now under construction) providing accommodation for large tankers to discharge and load mineral oils and chemicals in bulk.

Hull today handles the larger types of ocean freighters and there are sailings to and from all the principal ports of the world. The port is served by shipping lines to and from the Far East, India, Canada, U.S.A., South America, Africa, Australia and New Zealand, and its close geographical proximity to Scandinavia and other European countries gives Hull a leading position among U.K. ports for the import and export of merchandise to and from those countries.

at the west end of the quay and fruit sheds behind the quay at the east end. The quay was equipped with thirteen electric travelling cranes, ten of 3-tons capacity and three of 30-cwts. capacity. On the south side of Albert Dock behind Riverside Quay and extending for a length of about 1,350-ft. there was a range of transit sheds and warehouses, some dating from the original construction of the dock in 1867 and also completely destroyed by enemy action in 1941.

New Facilities Provided

The works which have now been provided, at a total cost of £1¾ million, will contribute valuably to the facilities and amenities of the Port of Hull. A length of 1,065-ft. of the old Riverside Quay at the eastern end has been replaced in open piled reinforced concrete construction, with a depth of water of 19-ft. 6-ins. at the lowest spring tides and over 40-ft. 0-ins. at the highest high water. Three transit sheds have been constructed on the quay, each 280-ft. 0-ins. long and 82-ft. 6-ins. wide, with 20-ft. headroom and with sliding doors at both front and back 18-ft. 8-ins. wide and 18-ft. 8-ins. clear height. To meet the desires of the local community, the right of way has been continued by a footpath



General layout of Riverside Quay and South Side, Albert Dock.

In the post-war years the British Transport Commission has spent several million pounds on rehabilitation and improvement works along the port's waterfront. As part of this scheme new port facilities comprising a reconstructed Riverside Quay and major developments along the south side of the adjacent Albert Dock, were formally opened, on May 12th last, by H.R.H. the Princess Royal. Apart from the new Riverside Quay, the works include a new south quay to Albert Dock, seven transit sheds, a passenger building, and a system of roads, railways and other facilities including eighteen wharf cranes.

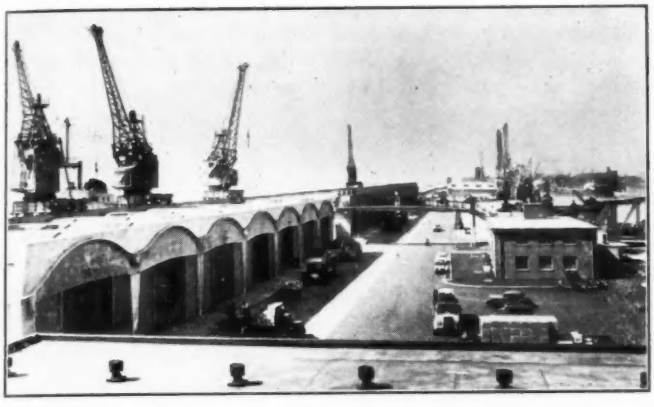
The former Riverside Quay was a wooden structure fronting directly on to the River Humber and, from its opening in 1907 by the then North Eastern Railway Company until its destruction by enemy action in 1941, had been a centre for the landing and distribution of fruit, vegetables and dairy produce from European countries. It was 2,500-ft. in length and was of open piled timber construction over a pitched slope, with a depth of 16-ft. 0-ins. of water at the lowest spring tides and 38-ft. 6-ins. at high water spring tides. Covered shed accommodation existed for the full length of the quay and an unusual feature was the perpetuation of a public right of way along the foreshore by an overhead footpath along the roof of the sheds. There was a passenger station over the roof of the two western sheds, and the City Corporation have contributed towards the cost involved. There is a width of quay of 25-ft. 0-ins. at the front of the sheds and a 10-ft. 0-ins. wide loading platform at the back served by two lines of railway track. The quay itself has no railway track, so that an entire unobstructed working area is available, and it is equipped with three 7½-ton and six 3-ton capacity semi portal level luffing electric cranes.

The new quay on the south side of the Albert Dock has four transit sheds, each 288-ft. 0-ins. x 82-ft. 6 ins. and a 40-ft. 0-ins. wide frontage to accommodate two lines of railway track. This frontage was gained by extending the existing quay forward into the dock by 40-ft. 0-ins. along its entire length in similar construction to that of the new Riverside Quay. The two groups of transit sheds are built in alignment so that the railway tracks which serve the rear of the Riverside sheds also run behind the second group, which are similarly equipped with a 10-ft. 0-ins. wide loading platform. The cranes are also of the same type, but comprise eight 6/3-ton, and one of 10-ton capacity.

Facilities for road vehicles are given by a 30-ft. 0-ins. wide roadway jointly serving Riverside Quay and the south side of Albert Dock, with parking areas and access between the sheds

to both quays. The railway tracks behind the sheds are flush paved so that road vehicles may also use the loading platforms. The loading platforms themselves contain culverts carrying the fresh water and electricity services, designed to give easy access for maintenance purposes.

At the east end of the Riverside Quay extensive passenger accommodation has been provided with all necessary amenities for the passengers themselves and for Customs and immigration



Overall view of the Riverside Quay (left) and South Side, Albert Dock (right) taken from above the Passenger building.

procedure. The passenger building is in contemporary style, constructed with reinforced concrete frames and panelled with glass and brick. Much attention has been paid to interior detail and the Waiting Room contains a fine mural depicting the traffic of the Humber from the Viking longship to the age of steam. A number of small buildings of modern construction and harmonising with the other works has been provided for staff dealing with traffic and maintenance operations, etc.

Details of Construction

When designing the works, considerable attention was given to speed of construction and reduction of maintenance. The new quays are founded on precast prestressed concrete piles made up of three sections, the top and bottom being short solid units and the centre section hollow. The three units are joined and stressed together by high tensile steel bars, extension pieces being added as necessary. Rigidity is imparted to the quay structure by the use of built-in rectangular precast reinforced concrete frames both transversely and longitudinally, and in order to avoid expensive shuttering over the water the deck is constructed of precast concrete units. To absorb the impact of ships during berthing operations a flexible fendering is provided consisting of hewn Greenheart piles supporting horizontal walings and rubbing strips to distribute berthing impacts, the whole being cushioned from the deck by rubber cylinders.

The transit sheds are constructed with a reinforced concrete framework and concrete barrel vault roofs with prestressed valley beams and are panelled with hollow concrete blocks. The thickness of the concrete at the crown of the barrels is 3¼ ins., and the design is such that no waterproofing membrane is necessary.

In order to ensure the high quality concrete essential to the type of construction, strict control methods were adopted with continuous testing in a site laboratory. A consistent ultimate concrete crushing strength of 7,500—8,000 lbs. per sq. inch was maintained; sometimes as much as 9,000 lbs. per sq. inch was achieved.

The total quantity of concrete used in the work was 36,000 cu. yds., with 2,300 tons of mild steel reinforcement and 70,000 lin. ft. of high tensile steel bars.

Difficulties encountered during pile driving led to the discovery of a buried timber jetty on the line of the new foundations. The timber of this structure was in excellent condition, although probably about 100 years old.

The Consulting Engineers were Sir Bruce White, Wolfe Barry and Partners, London, and the Contractors for the civil engineering work A. Monk & Co. Ltd., Warrington. The cranes were manufactured by Stothert and Pitt Ltd., Bath. Consultant for the passenger building was Dr. F. F. C. Curtis, Architect to the British Transport Commission.

Other Projects in Hand

The Riverside development scheme is the most expensive enterprise undertaken in the reconstruction of the Port of Hull. The work is one of three major projects which together will involve an outlay of £3 million. The other two schemes comprise the oil jetty improvements at Salt End and the reconstruction of a war-damaged section of Hull Fish Docks.

Salt End is becoming increasingly important as the Port's oil importing centre. Last year the total imports of petroleum were 2,026,272 tons, an increase of 12 per cent on the previous year's figure.

Improvement works in this area estimated to cost £1,100,000 are well in hand and involve the renewal of the No. 1 Jetty, as well as the provision of a new branch jetty. The works comprise a main approach projecting 1,167-ft. into the river and branching

D, E, F and G Sheds, South Side, Albert Dock, showing six of the nine cranes already erected.

into two for a further distance of 425-ft. with berthing heads, designed to accommodate ocean-going tankers of 27,000 tons deadweight. The new berths will be dredged to 36-ft. at M.L.W.S.

The No. 1 berthing head will be 258-ft. long and will accommodate one tanker or one coaster on the river face, and the No. 3 berthing head 396-ft. long will accommodate one tanker or two coasters on the river face and will provide three berths for river craft at the rear.

The new jetties provide for 57 pipe lines accommodated on three shelves. The main approach is in open piled reinforced concrete construction and the berthing heads are founded on Rendhex steel box piles with a concrete deck and curtain wall protected by cylindrical rubber buffers. The Consulting Engineers are Coode and Partners, London, and the Contractors the Yorkshire Hennebique Co. Ltd.

Port of Hull Reconstruction—continued

The other major project in hand is at the opposite end of the port where a length of the north quay at St. Andrew's Dock is under reconstruction, at an estimated cost of £420,000. Part of the brick-faced concrete gravity wall, forming the north quay, together with the timber-built Fish Market behind it, collapsed as a result of the explosion of a parachute mine in the dock water during the war. Subsequently the wall, weakened by this damage, collapsed in further sections, a length of 600-ft. of wall and Fish Market eventually being affected. A steel sheet piled cofferdam was driven to enclose the whole of the damaged wall, within which the old wall was demolished and a new mass concrete gravity wall built of heavier section than the old. At the same time the old wall on both sides of the length reconstructed has been tied back to prevent movement of furthe lengths. These tie bars, as well as the tie bars necessary fo the stability of the cofferdam, were placed by thrust boring fro trenches excavated in the railway tracks behind the Fish Marke A Fish Market of steel portal frame construction with asbesto cladding and provided with a box loft and offices for th merchants, is now being built for the full length of the new wal The Contractors for the cofferdam and dock wall reconstructio were the Demolition and Construction Co. Ltd., and for the new Fish Markets Shewell and Son (Successors) Ltd.

All the works described in this article were carried out unde the general supervision of the Chief Docks Engineer (Humber Ports) of the British Transport Commission.

New Firing Unit for Steam Cranes

By A. D. Barnett, B.Eng., A.M.I.Mar.E., Assoc.Inst.F.

The implementation of the Clean Air Act 1956 has seriously affected the operating of steam cranes in that it is an offence to emit smoke of a density of Ringelmann No. 2 or greater. With coal firing it is almost impossible to comply with this condition and it has therefore become necessary to burn expensive smokeless fuels or to convert the boiler to oil firing.

Until recent times oil has not been satisfactory for firing the vertical boiler used on a steam crane, because this is originally designed for burning solid fuel. Research into a suitable method for firing oil has been carried out by the Sayvoil Co., a subsidiary of Midland Industries Ltd., Heath Town Works, Wolverhampton and the new patented Sayvoil Firing Unit has resulted.

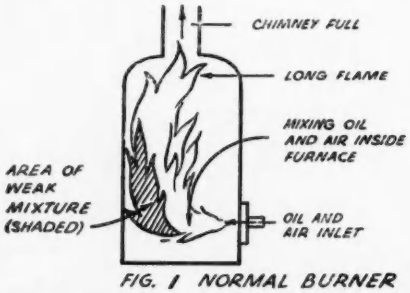
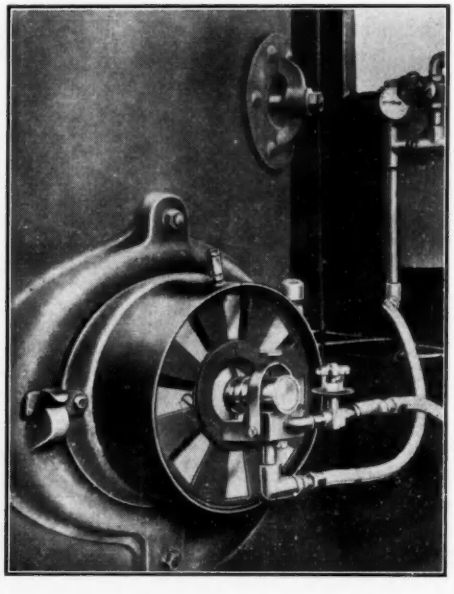


FIG. 1 NORMAL BURNER

The function of an oil burner is to atomise the oil and to admit the air required for combustion. In the past, oil firing equipment relied on mixing the atomised oil and the combustion air **inside** the furnace, in spite of the fact that in a vertical boiler it is not possible to obtain an efficient combustion mixture. The upward pull of the flue distorts the flame and areas of weak mixture result at the back as shown in Fig. 1. This leads to high chimney temperatures and poor efficiency.

In the Sayvoil Firing Unit the atomised oil and combustion air are mixed **outside** the furnace, and the mixture of highly combustible fuel is then fed into the furnace where spontaneous combustion takes place resulting in a short flame (see Fig. 2) with greatly reduced chimney loss and better steaming at a cheaper cost.

A seven-ton crane was recently fitted at Messrs. Thos. Smith & Sons (Rodley) Ltd., with the new oil-firing equipment as shown in Fig. 3 and tests were carried out to establish the performance and efficiency of the unit. The first set of tests included operating the steam crane with a coke fire and then carrying out a similar test using the oil-firing unit. In the coke-fired test 33 lifts were made in 37 minutes with an average boiler pressure of 88 lb. per sq. in., whilst in the oil-fired test 35 lifts were made in 38 minutes with an average pressure of 91 lb. per sq. in.


Sayvoil mixing chamber and control panel.

A standard vertical boiler was then fitted with the oil-firing equipment arranged for burning light fuel oil of 35 seconds viscosity Redwood, and also for 200 seconds viscosity Redwood medium fuel oil. Using coke and the two different types of oil three 6-hour steaming tests were carried out in which the amount of steam made and the fuel used was measured in order to establish the cost of operating a steam crane continuously on the various types of fuel. The cost per 100 lb. of steam worked out at 1s. 3d. for coke costing £7 per ton, 1s. 5½d. for 35 secs. oil costing 1s.4.7/8d. per gall., and 1s. 1½d. for 200 secs. oil costing 1s. 0.7/8d. per gall.

When estimating the cost of running a steam crane on oil it should be remembered that the savings are possible because, provided the boiler is lagged, the oil burner can be switched off during idle periods whereas a coke or coal fire continues to burn during this time. Furthermore banking at night is eliminated.

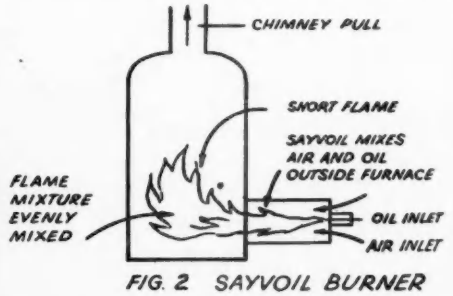


FIG. 2 SAYVOIL BURNER

Steam or compressed air is used for atomising the oil. Where compressed air is not available steam pressure is raised by means of solid fuel and the burner comes into operation when the pressure reaches 20 lb. per sq. in. of the gauge. However, it is normal to have compressed air laid on and the manufacturers can supply the small compressors necessary at a reasonable cost The furnace is so arranged that in excessively cold weather the boiler can be banked if required.

The makers guarantee that the emissions of smoke from a crane fitted with their equipment will comply with the requirements of the Clean Air Act, and in most cases a saving of fuel costs also results. The installation itself is carried out in the course of two days and instruction is given to the crane driver in the correct operation of the oil burner.